HYDROLOGY AND HYDRAULICS CRITERIA SUMMARY FOR
WESTERN ALAMEDA COUNTY

Revised
August 7, 1989

HYDROLOGY AND HYDRAULICS CRITERIA SUMMARY

WESTERN ALAMEDA COUNTY

INTRODUCTION

This Summary defines current District practice in the hydrologic and hydraulic design of flood control facilities in western Alameda County, and is written as a guide to be used by District engineers and engineers performing work for District review.

The criteria summarized here will be updated on a continual basis to reflect changes in District practice. The revision date of the Summary is shown on the inside cover and at the bottom left corner of each page. It is the responsibility of the user to determine that the Criteria Summary used for design is the current edition.

This Summary is intended for use by engineers familiar with generally accepted hydrology and hydraulic engineering design practice. Criteria not specifically detailed herein shall be determined in accordance with sound engineering practice. The Design Engineer should contact the Development Division in room 240 of the Public Works Agency with any questions regarding site specific design condiderations.

The Summary applies to western Alameda County only (Flood Control Zones 2, 2A, 3A, 4, 5, 6, 9, 12 and 13). It does not apply to eastern Alameda County (Flood Control Zone 7).

For information concerning Flood Control Zone 7 (eastern Alameda County) contact the Zone 7 offices located at 5997 Parkside Drive, Pleasanton, 94566, telephone 415/484-2600.

Copies of this Summary are available for $10.00 each in room 240 of the Public Works Building, 399 Elmhurst Street, Hayward. Telephone 415/670-5480.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF FIGURES

GLOSSARY

The following is a list of some of the abbreviated terms found in this Summary.

	Federal Emergency Management Agency
	Flood Insurance Study
EGL	Energy Grade Line
HGL	Hydraulic Grade Line
	Cubic Feet Per Second
	Mean Annual Precipitation
MHHW	Mean Higher High Water

HYDROLOGY AND HYDRAULICS CRITERIA SUMMARY

1. HYDROLOGY DESIGN

BACKGROUND

The two primary methods used by the District to determine design discharges are the modified Rational method and the unit hydrograph method. The Rational method is intended for use on small watersheds of less than 640 acres (one square mile), while the unit hydrograph method is intended for use on larger watersheds.

Waterways within the District are classified in three ways:

- <u>MAJOR FACILITIES</u> have a drainage area of ten square miles or more. Only Alameda Creek, San Lorenzo Creek and San Leandro Creek fall into this category.
- <u>PRIMARY FACILITIES</u> have a drainage area between fifty acres and ten square miles. These waterways or conduits are generally those designated for District maintenance.
- <u>SECONDARY FACILITIES</u> have a drainage area less than fifty acres and are conduits or small channels which are normally maintained by the local jurisdiction (for example, Cities or County maintained roads.)

For Primary facilities there is often more than one design storm to be considered in the analysis of the facility. This is because primary facilities must be designed to contain the Federal Emergency Management Agency (FEMA) 100-year storm in FEMA study areas as well as provide a <u>DESIGN STORM</u> water surface to which secondary facilities drain. All applicable design storms must be determined and measured against the appropriate hydraulic criteria to determine which storm will control under the varying hydraulic circumstances. It will be necessary to identify the system's Flood Control Zone (See Figure 1, Page 25), whether the facility is affected by tidal backwater, and whether the system was covered by the FEMA Flood Insurance Study (FIS) in order to determine the appropriate design storm or storms.

The design storm for primary facilities is a storm with a 15-year recurrence interval, except in Zone 12 where a 25-year storm interval is used. This storm is used to calculate a backwater curve using Mean Higher High Water as the beginning water surface at the Bay. In those reaches where primary facilities are subject to tidal backwater effects, a five-year storm must also be calculated and run against the 100-Year Tide for a second hydraulic grade line. The higher of these two water surfaces is to be used in design.

In addition, all facilities that are part of the FEMA Flood Insurance Study must be designed to contain the FEMA 100-year storm using FEMA criteria. Where these facilities are subject to tidal backwater effects, two water surface profiles must also be calculated and compared. The 100-Year Tide is run flat (no outflow from the channel), and the FEMA 100-Year flow is run against a beginning water surface of Mean Higher High Water. The higher of these two water surfaces controls for design. These criteria have been incorporated into this Summary.

The design storm for secondary facilities is one of 10-Year recurrence interval, regardless of zone.

The design of major waterways is beyond the scope of this summary. Their design shall be subject to the criteria established by the Deputy Director of Public Works - Design, at the time of design.

DESIGN STORM FOR PRIMARY FACILITIES.

1.1.1 NO OUTFLOW. All zones. All lines subject to tidal backwater effects and covered by the FEMA study.

1.1.2 5-YEAR STORM. All zones. All lines near the bay subject to tidal backwater effects.

1.1.3 15-YEAR STORM. All Zones except Zone 12. For all drainage areas up to ten square miles.

1.1.4 25-YEAR STORM. Zone 12 only. For all drainage areas up to ten square miles.

1.1.5 FEMA 100-YEAR STORM. All Zones. For all reaches of the flood control system covered by the FEMA flood insurance study. The flows to be used in design are found in the Flood Insurance Study for the particular line. These studies are available at the District offices and from FEMA.

1.1.6 LINE SPECIFIC CRITERIA.

Alameda Creek, Bay to Zone 7 Boundary: STANDARD PROJECT FLOOD.*

San Lorenzo Creek, Bay to junction of Cull and Crow Canyon Creeks: STANDARD PROJECT FLOOD.*

San Leandro Creek, Bay to Lake Chabot: 2800 cfs.

* See Figure 2, Page 26, for calculating the Standard Project Flood.

1.2 DESIGN STORM FOR SECONDARY FACILITIES.

1.2.1 10-YEAR STORM. All Zones. All secondary facilities.

RATIONAL METHOD OF ESTIMATING PEAK RUNOFF.

A modified Rational Formula shall be used to determine the peak discharge of a watershed for areas up to 640 acres (one square mile). All hydrology calculations using the Rational Method shall be entered into Form 21.2 for District maintained projects and for in-tract drainage submittals. A reduced copy of this form is shown in Figure 3 on Page 27. Copies of the form to be used are available at the District's Elmhurst Street offices.

The overall watershed shall be broken down into smaller areas which contribute to local points of concentration. The boundaries shall be established based upon local topographic boundaries such as ridges, streets, existing drainage systems, etc, using good engineering practice.

The design flow rate shall be calculated using the District Modified Rational Formula, which is:

$$Q = i \ (C` A) \qquad \text{Eq. 1-1}$$

where:

Q is the design runoff flow rate in cubic feet per second;
i is the rainfall intensity in inches per hour;
C` is a runoff coefficient modified by slope and rainfall intensity;
A is the drainage area in acres.

1.3.1 <u>TIME OF CONCENTRATION</u>.

The time of concentration is the time required for the runoff from the most remote region of the watershed to reach the point of concentration at which the flow is to be calculated. It is composed of two parts, the <u>initial time of concentration</u>, sometimes referred to as the <u>inlet time</u>, and the <u>conduit time</u>. A minimum time of concentration based upon the hydraulic conditions which maximize flow velocities shall be used to design the flood control system.

1.3.1.1 <u>INITIAL TIME OF CONCENTRATION</u>. The initial time of concentration (Initial T_c) is that time required to wet the surface, fill depressions and establish runoff at the first point of concentration in the watershed. Often this first point of concentration is the first inlet of the storm water system. This time will seldom be less than three minutes nor more than 20 minutes. The Initial Time of Concentration shall be determined using the following criteria:

1.3.1.1.1 <u>UNDEVELOPED WATERSHEDS</u>.

$$\text{Initial } T_c = \frac{L}{60(V)} \qquad \text{Eq. 1-2}$$

Where:

T_c = Time of concentration in minutes
L = Overland flow length in feet
V = Overland flow velocity in feet per second from Figure 4, Page 28.

1.3.1.1.2 URBANIZED WATERSHEDS.

In urbanized watersheds the initial time of concentration shall be taken as a "roof-to-gutter" time plus the time required for the water to flow from the upper most part of the drainage basin to the initial point of concentration.

Roof-to-gutter time is a function of ground slope and type of facility and therefore varies. See Figure 5, Page 29, to find the roof-to-gutter time to be used in design.

The time for the water to reach the first inlet shall be estimated using the gutter flow chart (Figure 6, Page 30). Other charts for flow in small conduits or gullies, when used, shall be referenced.

These two times shall then be added to find the Initial Time of Concentration.

1.3.1.2 CONDUIT TIME.

Conduit time is the length of time required for the water to flow from one point of concentration, or inlet, to the next. The chosen average velocity or weighted incremental velocities must accurately reflect the hydraulic conditions within the storm water system. Where the flow takes place in natural streams, the velocity should be determined using Figure 7, Page 31, or other appropriate method.

1.3.2 RAINFALL INTENSITY.

Rainfall intensity is the product of the Unit Rainfall Intensity Factor and the Mean Annual Precipitation (MAP) and is expressed in inches per hour.

The unit rainfall intensity factor for the appropriate time of concentration and storm recurrence interval is found in Figure 8, Pages 32 and 33.

The mean annual precipitation is found on the District's isohyetal map, file No. MA-180. A copy of this map is included at the back of this Summary, and a reduced copy is shown in Figure 9, Page 34. The MAP to be used is located at the center of gravity of the entire drainage area above the specific point of concentration.

1.3.3 RUNOFF COEFFICIENT - BACKGROUND.

A modified runoff coefficient C' is to be used in the design of flood control facilities for the District. This modified coefficient is made up of a basic runoff coefficient C, a ground slope factor Cs, and a rainfall intensity factor Ci.

The basic runoff coefficient shall be chosen to reflect the ultimate development of the drainage area. This will be based on City/County General Plans. If General Plans are not available, then a reasonable ultimate land use shall be assumed.

The slope adjustment factor Cs is used to adjust for increases in runoff as the average slope of the incremental drainage area increases. Note: the slope to be used to find Cs is not the slope of the incremental waterway but that of the land draining to that waterway.

The intensity factor Ci is used to reflect the decrease in soil permeability that can be expected with increased rainfall intensity.

1.3.4 RUNOFF COEFFICIENT - CALCULATION.

The formula for calculating the modified runoff coefficient is:

$$C' = C + Cs + Ci \qquad \text{Eq. 1-3}$$

where:

C	LAND USE DESCRIPTION	PERCENT IMPERVIOUS
0.2*	Undeveloped land, Parks, Golf courses	0%
0.4	Single Family Residential	30%
0.6	Condominiums, Apartments, Institutions Mobile Home Parks, Light Industrial	55%
0.7	Medium Industrial	70%
0.8	Commercial, Heavy Industrial	85%
0.9	Impervious (Streets, Parking lots, Roof tops	100%

* The basic runoff coefficient shall be increased in areas with soils having low permeability, .

Note: C is computed based on weighted area times runoff using 0.2 for open space and 0.9 for impervious areas.

$$Cs = \frac{(0.8 - C)(Ln(S - 1))\ S^{0.5}}{56} \qquad \text{Eq. 1-4}$$

$$Ci = (0.8 - (C + Cs))\left|1 - \frac{1}{(1/_{e}i) + (Ln(i + 1))}\right| \qquad \text{Eq. 1-5}$$

and where:

C` is the design runoff coefficient.
C is the base weighted runoff coefficient.
Cs is the slope adjustment factor.
Ci is the rainfall intensity adjustment factor.
S is the average ground slope of the incremental drainage area in percent.
i is the design storm rainfall intensity (inches/hour).

C' may be found using Figure 10, Pages 35 to 37, using the selected basic weighted runoff coefficient C, known ground slope and rainfall intensity (in inches per hour).

The modified runoff coefficient (C') will never exceed 0.80 when calculations are based on land use. When calculations are based on type of surface (for example, when calculating the runoff from a small, impervious area such as a parking lot) the basic runoff coefficient (C) shall be determined in accordance with sound engineering practice, and may often exceed 0.80.

1.4 FLOOD HYDROGRAPH.

The Soil Conservation Service (SCS) Unit Hydrograph Method shall be used to determine the peak discharge for drainage areas greater than 640 acres and whenever the volume of water during a design storm is required. The temporal rainfall distribution used in this analysis shall be the Alameda County Type I Storm Distribution for the 24-hour accumulated rainfall. The ordinates for this distribution are provided in Figure 11, Page 38. Runoff curve numbers for hydrologic soil-cover conditions may be taken from Reference 7, Table 9.4, Page 9.8. In lieu of determining the flood hydrograph and its associated peak discharge by hand computation, the SCS TR-20 or Army Corps of Engineers HEC1 hydrologic computer modelling programs using Alameda County Type 1 Storm distribution data may be used. See references 1 and 7 for more detailed explanation of the methods.

2. HYDRAULIC DESIGN

BACKGROUND

The District uses Mannings' equation to calculate friction losses, and the pressure-momentum method and energy equations to calculate major junction or section change losses (the higher water surface resulting from the use of these equations is to be used). For uncommon design problems, the design engineer shall provide suitable tests or references as needed to confirm the proposed design.

Primary facilities serve two basic purposes: they contain the large (100-year recurrence) storms, and they provide a design storm water surface that is adequate for the positive drainage of secondary facilities.

Secondary facilities drain smaller watersheds and are designed to drain positively to the design storm water surface in the primary facility.

Some secondary facilities drain directly to the Bay. These facilities are designed to drain to the 100-Year Tide.

The beginning water surface to be used in calculating hydraulic profiles is dependent on the type of facility (primary or secondary), the design storm recurrence interval, and whether the facility is subject to tidal backwater effects.

Figure 12 on Page 39 is a list of the various datum planes used by different jurisdictions in the Bay Area. Figure 13 on Pages 40 to 42 illustrates tidal elevations to be used in design. Figure 14 on Page 43 is a summary of the design water surfaces described in this chapter.

HYDROLOGY AND HYDRAULICS CRITERIA SUMMARY

DESIGN WATER SURFACE FOR PRIMARY FACILITIES.

The following beginning water surfaces shall be used when calculating design water surfaces for primary facilities:

2.1.1 NO OUTFLOW. Use the 100-Year Tide.*

2.1.2 5-YEAR STORM. Use the 100-Year Tide

15/25-YEAR STORM. Use Mean Higher High Water (MHHW).

FEMA 100-YEAR STORM. Use Mean Higher High Water (MHHW).*

* These are FEMA criteria required in all reaches of lines that are part of the FEMA Flood Insurance Study.

Note: In areas subject to tidal influence, the design water surface shall be the higher of the 5-Year and 15/25-Year profiles as calculated above.

2.1.5 NO TIDAL INFLUENCE.

Use the closest known downstream water surface for the required design storm. If no water surface is known in the primary facility, one shall be calculated beginning at the nearest point of hydraulic control or at the Bay, if necessary, using the above criteria.

DESIGN WATER SURFACE FOR SECONDARY AND OTHER FACILITIES.

The design water surface for all secondary facilities is the 10-Year Hydraulic Grade Line. The following beginning water surfaces shall be used when calculating water surfaces for secondary facilities.

2.2.1 SECONDARY FACILITIES DRAINING TO PRIMARY FACILITIES.

Use the current District Design Water Surface. If none is available, design shall conform to the Freeboard Requirements of Section 2.3 herein.

2.2.3 SECONDARY FACILITIES DRAINING DIRECTLY TO THE BAY.

Use the 100-Year Tide

2.2.4 PRIMARY AND SECONDARY FACILITIES DRAINING TO MAJOR FACILITIES (ALAMEDA, SAN LEANDRO AND SAN LORENZO CREEKS).

Use the current District Design Water Surface.

NOTE: For Secondary Facilities draining to Primary Facilities in FEMA studied areas only, the HGL(10) shall also be calculated using the FEMA HGL(100) in the Primary Facility as a starting water surface. The HGL(10) in the Secondary Facility shall not exceed Top of Curb.

2.3 FREEBOARD REQUIREMENTS for all facilities shall be as follows:

FACILITY	FREEBOARD (FT.)	FROM DESIGN HGL UP TO:
Closed Conduit	1.25	Top of Curb
Non-leveed Channels		
District Design Storm	1.00	Top of Bank
FEMA Q(100)	0.00	Top of Bank
Leveed Channels		
Tidal	3.00	Top of Levee
Non Tidal		
District Design Storm	1.00	Top of Levee
FEMA Q(100)	3.00	Top of Levee
FEMA Q(100)	4.00	Top of Levee within 100 feet downstream of constrictions
FEMA Q(100)	4.50	Top of Levee within 100 feet upstream of constrictions
Street Crossings	2.00	Soffit(top of conduit) or provide 100-year design storm capacity
Bayfront Levees	1.00*	Top of Levee
Retention/Detention Pond	1.00	Top of Ground

* Bayfront Levee freeboard shall conform to the current FEMA requirements as outlined in 44CFR Part 65.10(a)(1)(iii), which includes wave runup.

2.4 HYDRAULIC PROFILE: FRICTION LOSSES. The Mannings Formula shall be used to calculate hydraulic profiles. The friction value "n" is as follows:

TYPE OF FACILITY	"n"
Reinforced Concrete Pipe	
Primary Facilities	0.012
Secondary Facilities	0.014
Corrugated Metal Pipe	
Annular	0.021
Helical	0.018
Concrete-Lined Channels	
Smooth-troweled	0.015
District Simulated Stone	0.017
Reinforced Concrete Box	
Cast-in-Place	0.015
Pre-Cast	0.014
Gabions, mats, and other patented designs	Consult manufacturers specifications.
Earth Channels	
Smooth Geometric	0.030 minimum
Irregular or Natural	ref. 2, pp 106-109, pp 136-140

For curved channels or closed conduits, the "n" value should be increased as follows:

$$+n = \frac{0.29}{R} \qquad \text{Eq. 2-1}$$

where:

$+n$ is the adjustment (to be added) to the "n" selected for the facility
R is the Radius at center line in feet.

Note: For radii less than 20 feet bend losses shall be calculated.

<u>HYDRAULIC PROFILE: JUNCTION LOSSES</u>. At points of change in the hydraulic parameters of flow rate or section, the HGL and Energy Grade Line (EGL) shall be calculated considering velocity heads and losses due to bends, entrances, exits, turbulence, etc. The Pressure-Momentum method should be used to calculate the change in water surface at major junctions and section changes with a corresponding recalculation of the EGL, as follows:

$$y = \frac{Q_2V_2 - Q_1V_1\cos\theta_1 - Q_3V_3\cos\theta_3}{g\left|\frac{A_1 + A_2}{2}\right|} \qquad \text{Eq. 2-2}$$

where:

y = Change in hydraulic gradient through junction, in feet.
Q = Flow in cubic feet per second (cfs).
V = Velocity, feet per second.
A = Area of flow, square feet (ft^2)
θ_3 = Angle of convergence between the center line of the main line and the center line of the lateral (degrees).
θ_1 = Angle of deflection between the upstream and downstream center lines, in degrees.
g = Acceleration due to gravity, 32 ft per sec^2.

Energy equations should be used to calculate the effect a section change has on the EGL and compared with the Pressure-Momentum results. The higher of the two is to be used. The District's hydraulic programs do this automatically.

<u>HYDRAULIC PROFILE: HYDRAULIC JUMPS</u>. Hydraulic jumps occur when the depth of flow changes rapidly from a low stage to a high stage. Where hydraulic jumps are likely to occur, such as where the slope or cross section of the facility changes in supercritical flow, their location and energy losses shall be determined and considered in the design. See Reference 2, pp 393-434.

2.7 LIMITING VELOCITIES AND MINIMUM INVERT SLOPE.

FACILITY	MIN. VELOCITY ft/sec	MAX. VELOCITY ft/sec	MIN. SLOPE ft/ft
Earth Channels	2.0	6.0	0.0007
Concrete Lined Channels	2.0	14.0	0.0007
Closed Conduits	3.0	14.0	0.0007

2 is OK for City

Where velocities are greater than 14 ft./sec., special criteria shall be established on a case by case basis to provide for scouring, maintenance or uneven flow conditions.

2.8 HIGH VELOCITY FLOWS which result from facilities on steep slopes shall consider roll waves and pulsating flows in the design.

2.8.1 ROLL WAVES are created when the normal depth of flow is within ten percent of the critical depth for the section. This condition should be avoided.

2.8.2 SLUG FLOW is a pulsating flow of waves which tend to amplify. The Vedernikov Number, or V-No., is a measure of the tendency for supercritical flow stability. Where the V-No. is greater than unity, any wave created in the facility will tend to amplify up to a maximum height of 1.65 times normal depth, given a suitable length of run. Where this condition cannot be avoided, closed conduits shall be sized such that normal depth does not exceed half the depth of the conduit, and open channels shall be lined at least to 1.70 times normal depth. See Reference 2, pp. 210-211.

2.8.3 EFFECTS OF CURVATURE. In open channels of curved alignment, the rise in the water surface due to superelevation and cross waves shall be considered.

2.8.3.1 Superelevation is the rise in water surface around a bend in a channel due to centrifugal force. The rise in the water surface is given by:

$$h = \frac{V^2 b}{2gr_c} \qquad \text{Eq 2-3}$$

where:

h = rise in water surface, in feet.
V = velocity, feet per second.
b = channel width at the water surface.
r_c = radius of channel centerline.

2.8.3.2 Cross Waves occur in supercritical flow and should be considered in design. See Reference 2, Page 448.

2.8.4 AIR ENTRAINMENT. Velocities above 14 ft./sec. entrain air. An increased depth may result, with this depth being related directly to the increase in the volume of water.

$$A_a = 10 \left| \frac{0.2\ V^2}{g\ R} - 1 \right|^{0.5} \qquad \text{Eq. 2-4}$$

where:

A_a is the increase in flow area attributable to air entrainment in percent.
V is the velocity at normal depth in feet per second.
R is the hydraulic radius without air entrainment.
g Acceleration due to gravity, 32.2 ft per sec^2.

See Reference 2, p. 36

2.9 STORM WATER HOLDING FACILITIES.

2.9.1 Retention Facilities are designed to contain approximately 25 percent of the Mean Annual Precipitation regardless of the design storm frequency of the drainage facilities entering the facility. The facility shall be designed such that the water surface returns to its original elevation within 24 hours. The volume of storm water shall be calculated as follows:

$$Vw = 0.021\ P\ A \qquad \text{Eq 2-5}$$

where:

Vw is the volume of water to be stored in acre-feet.
P is the annual precipitation at the center of gravity of the drainage basin in inches.
A is the drainage area in acres.

2.9.2 Detention Facilities are those facilities designed to reduce the rate of discharge to an outlet drainage facility. The discharge shall be controlled by the outlet works such that the predetermined discharge rate from the detention facility, and the peak flow in the receiving facility, are not exceeded. The required pond storage shall be computed using flood routing techniques with a unit hydrograph. The SCS method (ie., TR-55, etc.) may be used to develop storm hydrographs and routing calculations when designing storage and outlet drainage works. The pond shall be designed such that the water surface returns to its base elevation within 24 hours.

One of the common uses for a Detention Facility is to limit the augmented discharge from a development site. When such a facility becomes a permanent drainage feature, assurances for its continued maintenance in its designed capacity must be provided for; ie., maintenance by the District, another public agency, or private party through a maintenance agreement.

Several types of detention facilities are acceptable to the District for controlling on-site the augmented storm discharge:

- o Parking lot detention for industrial/business development. Using this method requires the filing of notice that the area is subject to storm water ponding. Parking lots shall provide pedestrian access through the ponded areas. Depths of ponding shall not exceed four inches (4").

- o Conduit storage can be utilized by oversizing the underground drainage facilities. Care should be taken to prevent siltation problems.

- o Channel storage can be utilized by oversizing the open channel facilities. Care again should be taken to prevent siltation problems, and allowances must be made for a minimum capacity at a maximum silt buildup.

- o Multi-purpose facilities can be used as detention facilities such as park areas, tennis courts, parking areas, existing ponds and wetland areas, and landscaped areas.

2.10 DEBRIS AND SEDIMENT BASINS.

Debris and sediment basins may be required in the design of certain flood control facilities. The need for such structures shall be determined on a site by site basis by the Director of Public Works.

3. RIGHT-OF-WAY

3.1 DISTRICT MAINTAINED PROJECT MINIMUM RIGHT OF WAY REQUIREMENTS are as shown on Figure 15, Pages 44 and 45, for District projects.

3.2 MINIMUM SET BACK REQUIREMENTS. Under the Alameda County Watercourse Protection Ordinance, the minimum requirements for set backs are as shown on Figure 16, Page 46. See also Reference 10.

4. MISCELLANEOUS STANDARDS

DISTRICT SPECIFICATIONS AND STANDARDS for backfill, concrete products, pipe, etc., and District Design Guidelines shall be used where applicable.

MINIMUMS. These minimums cover items not covered elsewhere in this summary.

4.2.1 MINIMUM PIPE SIZE shall be 12-inches in diameter.

2 MINIMUM REINFORCED CONCRETE BOX HEIGHT shall be seven feet where grades permit.

4.2.3 MINIMUM BOTTOM WIDTH FOR OPEN CHANNELS AND BOXES shall be four feet for earth sections and six feet for concrete sections whenever possible.

MAXIMUMS. These maximums cover items not covered elsewhere in this summary.

4.3.1 MAXIMUM EGL ELEVATION shall be below the top of bank in channels and below ground in closed conduit systems wherever possible.

4.3.2 MANHOLE SPACING FOR UNDERGROUND CONDUITS shall not exceed 400 feet on center.

4.3.3 SIDE DRAIN SPACING FOR OPEN CHANNELS shall be such that a minimum two percent (2%) slope is maintained between grade break and side drain inlet, and in no case shall be greater than 400 feet.

4.3.4 SIDE SLOPE FOR EARTH CHANNELS shall be no steeper than two and one half (2-1/2) horizontal to one (1) vertical.

FUTURE CROSSINGS of District open channels shall be either clear span or shall not adversely increase the water surface elevation for any cross-section of the channel upstream of the crossing for the appropriate design storm.

UNDERGROUNDING OF EXISTING DISTRICT OPEN CHANNELS shall not adversely increase the water surface elevation for any cross-section of the channel upstream for the appropriate design storm.

4.6 CAST-IN-PLACE CONCRETE PIPE. Precast reinforced concrete pipe is the accepted material for concrete culverts. The use of Cast-In-Place pipe is subject to the approval of the Deputy Director of Public Works - Design, on a case by case basis.

5. REFERENCES

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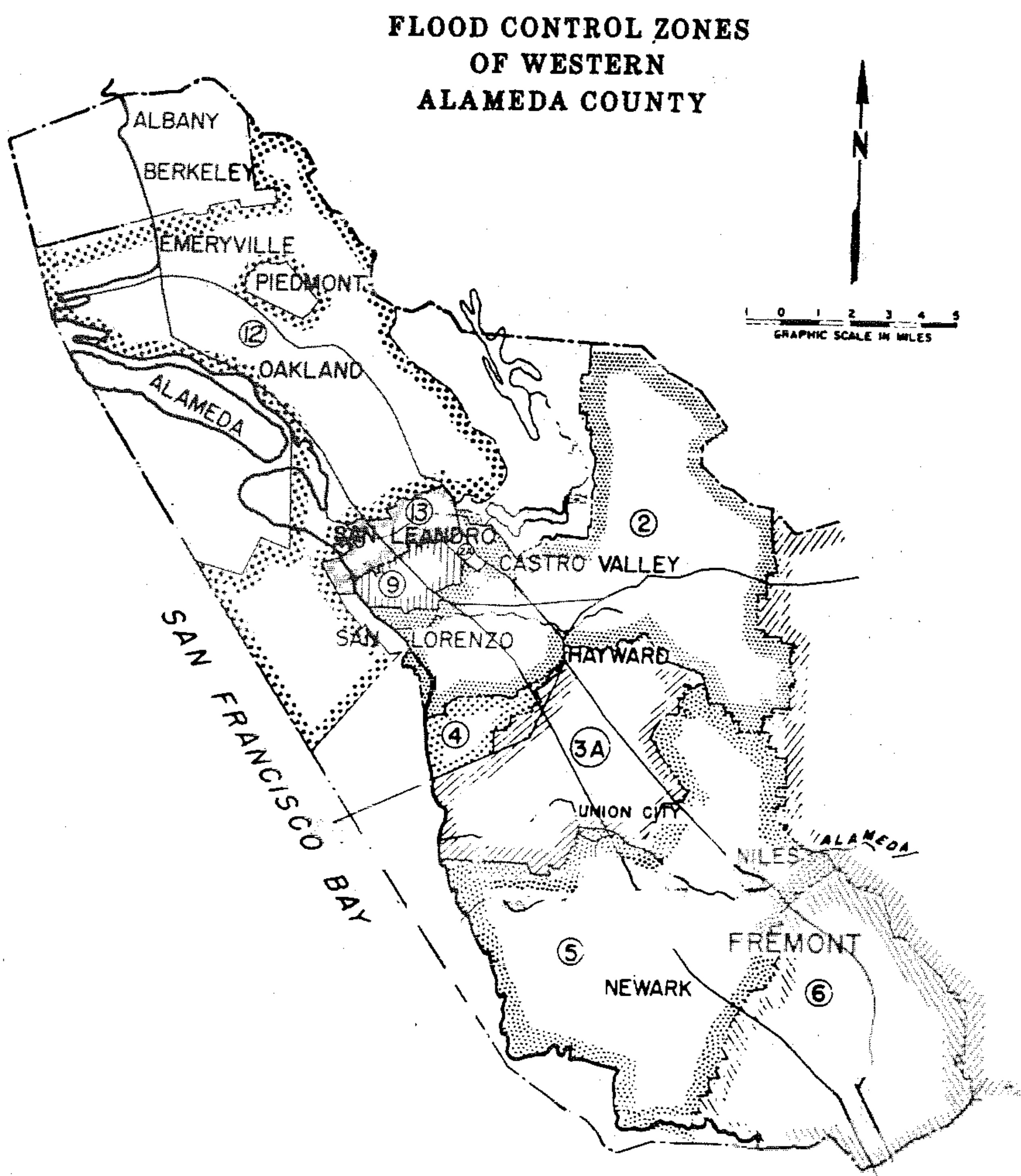
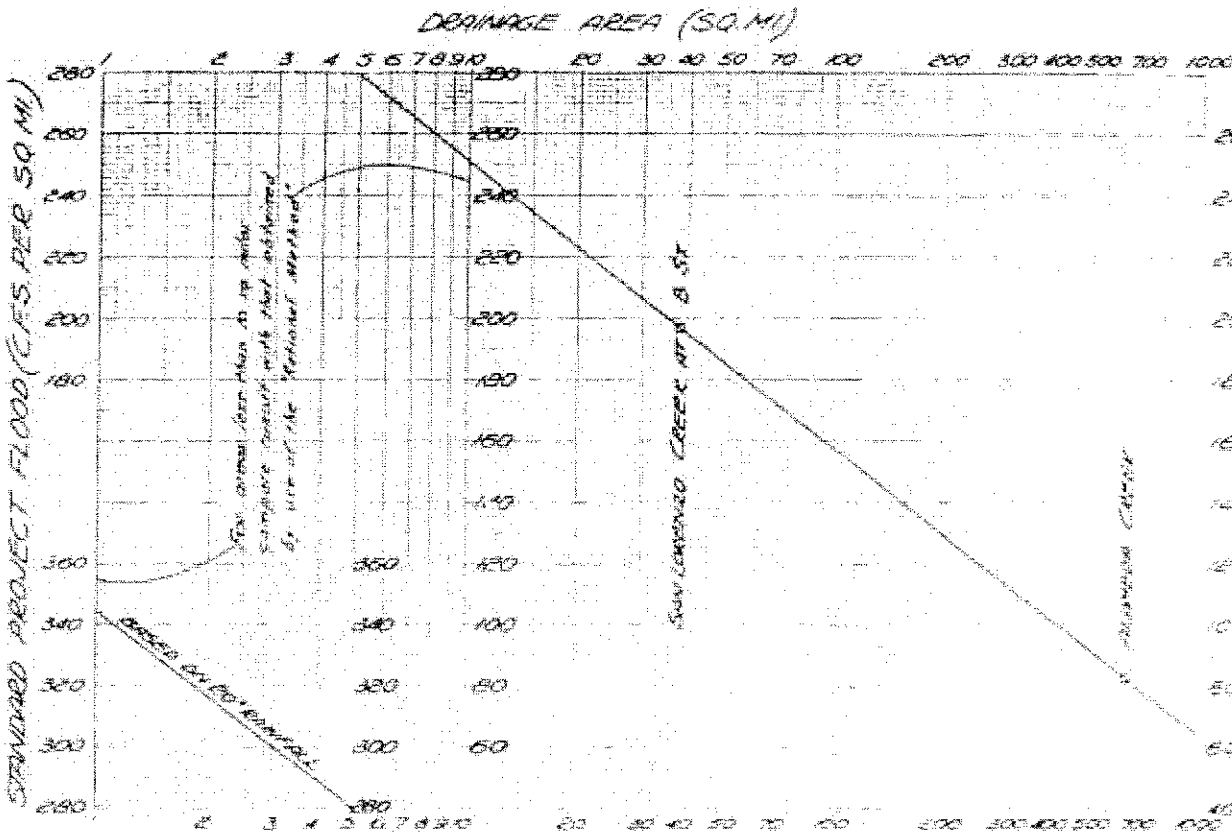
10. County of Alameda, "Watercourse Protection Ordinance of Alameda County-," Ordinance Code of Alameda County, Title 7, Chapter 10.

11. U.S. Army Corps of Engineers, San Francisco District, "San Francisco Bay Tidal Stage vs. Frequency Study," October, 1984.

APPENDIX



ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	ZONE BOUNDARY MAP	DATE: FEBRUARY 1987
		FIGURE 1



ALAMEDA COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

STANDARD PROJECT FLOOD

DATE: FEBRUARY 1987

FIGURE 2

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

SAMPLE HYDROLOGY CALCULATION FORM

DATE: FEBRUARY 1987

FIGURE 3

ZONE__________ LINE________________

DATE__________ BY__________ CK BY________

DRAINAGE AREA MAP NO.________

REF.________________

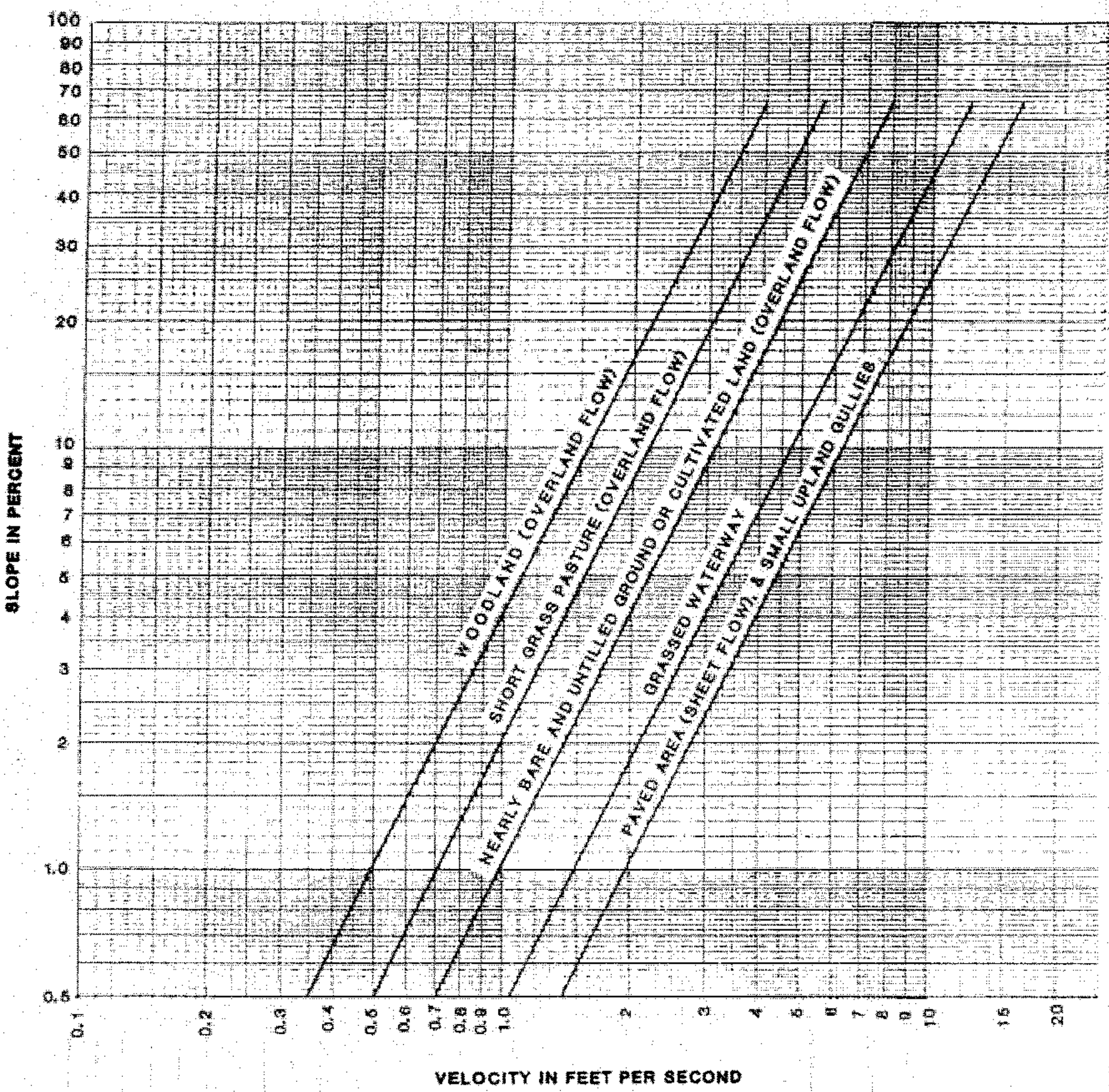
* INITIAL Tc __________

** P to be taken at center of

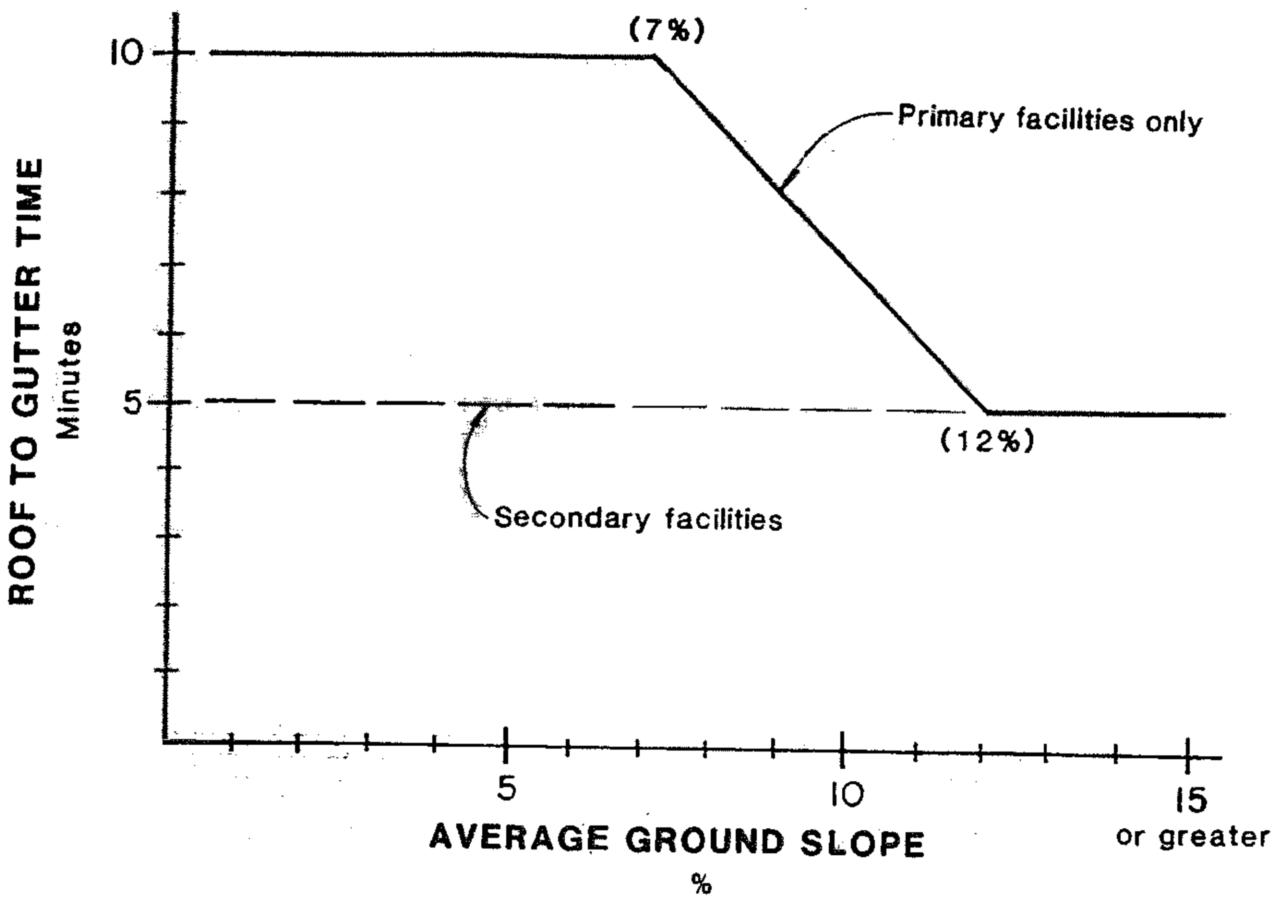
HYDROLOGY CALCULATIONS

COMMENTS	POC	Tc*	RAINFALL			INCREMENTAL AREA					ACCUMULATED AREA		Q=ΣIΣAC'	CO
			UNITY INTENSITY Ix	MAP P**	INTENSITY (Ix)·(P) IN/HR	AREA DESIG.	ΔA ACRES	ΔA AVG SLOPES	C'	ΔAC'	ΣA ACRES	ΣAC'	DESIGN Q( )	

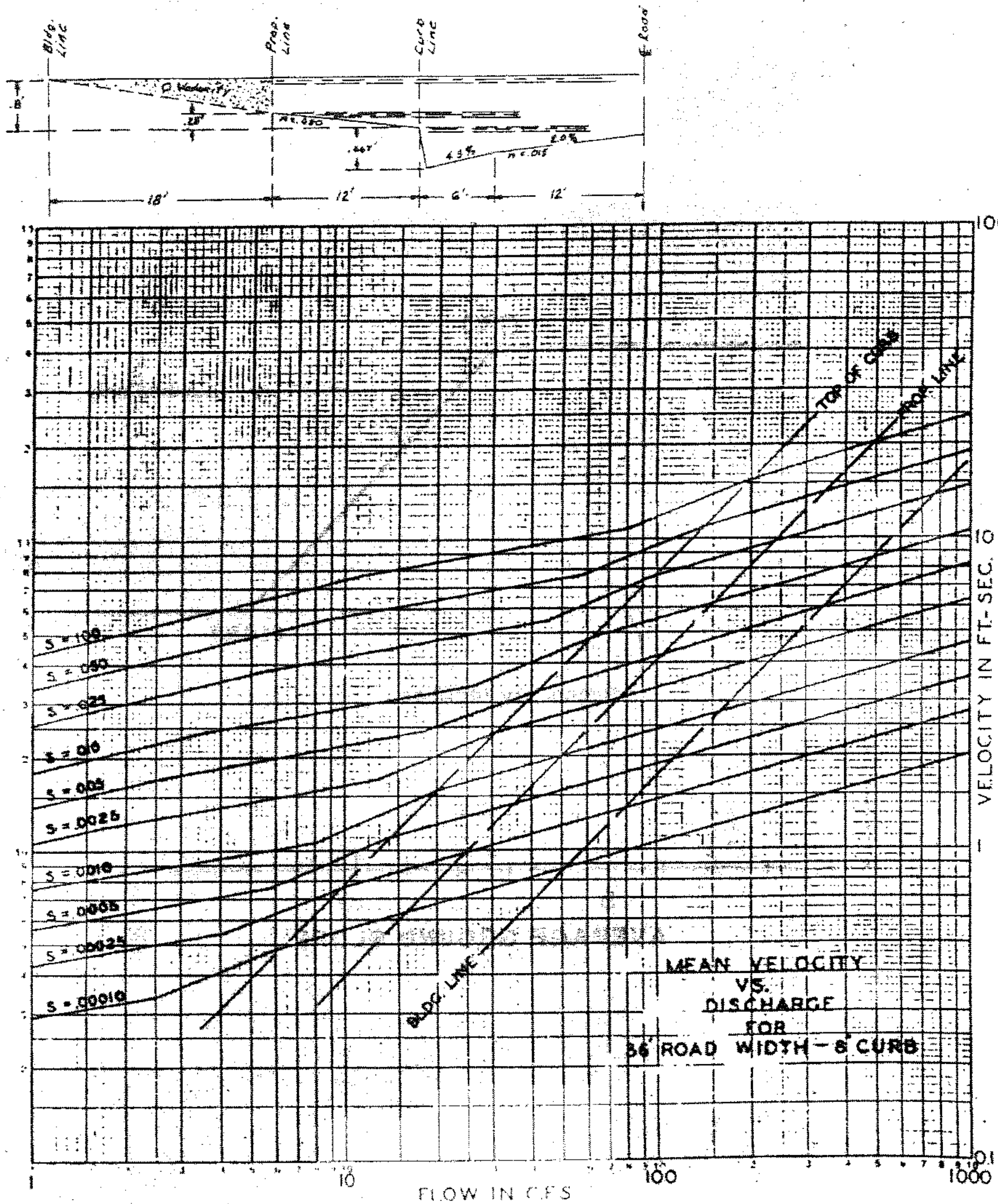
SAMPLE



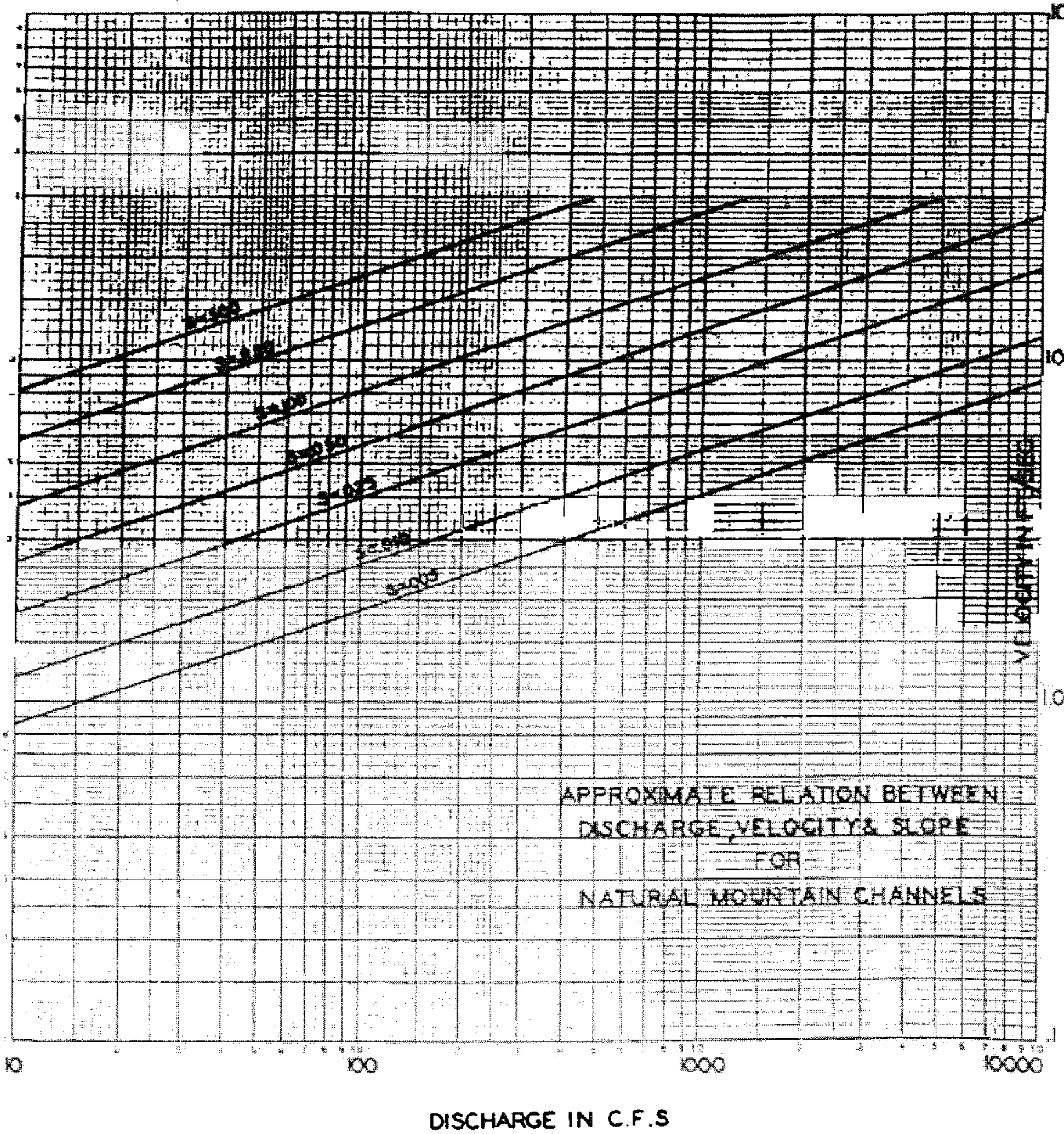
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	**OVERLAND FLOW VELOCITY CHART**	DATE: FEBRUARY 1987 **FIGURE 4**



ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	**ROOF TO GUTTER TIME CHART**	DATE: **FEBRUARY 1987**
		FIGURE 5



ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	GUTTER FLOW CHART	DATE: FEBRUARY 1987
		FIGURE 6



ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	**NATURAL CHANNEL FLOW CHART**	DATE: FEBRUARY 1987
		FIGURE 7

UNIT RAINFALL INTENSITY FACTOR CHART, Ix PER HOUR

Tc	RECURRENCE INTERVAL					Tc	RECURRENCE INTERVAL					Tc	RECURRENCE INTERVAL				
(min)	5 YRS	10 YRS	15 YRS	25 YRS	100YRS	(min)	5 YRS	10 YRS	15 YRS	25 YRS	100YRS	(min)	5 YRS	10 YRS	15 YRS	25 YRS	100YRS
1	.184	.219	.234	.264	.327	41	.041	.048	.052	.059	.073	81	.029	.034	.036	.041	.051
2	.164	.195	.209	.236	.292	42	.040	.048	.051	.058	.072	82	.028	.034	.036	.041	.051
3	.144	.171	.182	.206	.255	43	.040	.047	.051	.057	.071	83	.028	.034	.036	.041	.050
4	.128	.152	.163	.184	.228	44	.039	.047	.050	.056	.070	84	.028	.033	.036	.040	.050
5	.116	.138	.148	.167	.207	45	.039	.046	.049	.056	.069	85	.028	.033	.035	.040	.050
6	.107	.127	.136	.154	.190	46	.038	.046	.049	.055	.068	86	.028	.033	.035	.040	.049
7	.100	.118	.126	.143	.177	47	.038	.045	.048	.055	.068	87	.028	.033	.035	.040	.049
8	.093	.111	.119	.134	.166	48	.038	.045	.048	.054	.067	88	.027	.033	.035	.039	.049
9	.088	.105	.112	.126	.157	49	.037	.044	.047	.053	.066	89	.027	.032	.035	.039	.048
10	.084	.099	.106	.120	.149	50	.037	.044	.047	.053	.065	90	.027	.032	.034	.039	.048
11	.080	.095	.101	.114	.142	51	.036	.043	.046	.052	.065	91	.027	.032	.034	.039	.048
12	.076	.091	.097	.110	.136	52	.036	.043	.046	.052	.064	92	.027	.032	.034	.038	.048
13	.073	.087	.093	.105	.130	53	.036	.042	.045	.051	.064	93	.027	.032	.034	.038	.047
14	.071	.084	.090	.101	.126	54	.035	.042	.045	.051	.063	94	.026	.031	.034	.038	.047
15	.068	.081	.087	.098	.121	55	.035	.042	.044	.050	.062	95	.026	.031	.033	.038	.047
16	.066	.078	.084	.095	.117	56	.035	.041	.044	.050	.062	96	.026	.031	.033	.038	.047
17	.064	.076	.081	.092	.114	57	.034	.041	.044	.049	.062	97	.026	.031	.033	.037	.046
18	.062	.074	.079	.089	.111	58	.034	.041	.043	.049	.061	98	.026	.031	.033	.037	.046
19	.060	.072	.077	.087	.108	59	.034	.040	.043	.049	.060	99	.026	.031	.033	.037	.046
20	.059	.070	.075	.084	.105	60	.034	.040	.043	.048	.060	100	.026	.030	.032	.037	.046
21	.057	.068	.073	.082	.102	61	.033	.039	.042	.048	.059	101	.025	.030	.032	.037	.045
22	.056	.067	.071	.080	.100	62	.033	.039	.042	.047	.059	102	.025	.030	.032	.036	.045
23	.055	.065	.070	.079	.098	63	.033	.039	.041	.047	.058	103	.025	.030	.032	.036	.045
24	.054	.064	.068	.077	.095	64	.032	.038	.041	.046	.058	104	.025	.030	.032	.036	.045
25	.053	.062	.067	.075	.093	65	.032	.038	.041	.046	.057	105	.025	.030	.032	.036	.044
26	.052	.061	.065	.074	.092	66	.032	.039	.040	.046	.057	106	.025	.029	.031	.036	.044
27	.051	.060	.064	.072	.090	67	.032	.038	.040	.045	.056	107	.025	.029	.031	.035	.044
28	.050	.059	.063	.071	.088	68	.031	.037	.040	.045	.056	108	.025	.029	.031	.035	.044
29	.049	.058	.062	.070	.087	69	.031	.037	.040	.045	.055	109	.024	.029	.031	.035	.043
30	.048	.057	.061	.069	.085	70	.031	.037	.039	.044	.055	110	.024	.029	.031	.035	.043
31	.047	.056	.060	.068	.084	71	.031	.036	.039	.044	.055	111	.024	.029	.031	.035	.043
32	.046	.055	.059	.066	.082	72	.030	.036	.039	.044	.054	112	.024	.029	.031	.035	.043
33	.046	.054	.058	.065	.081	73	.030	.036	.038	.043	.054	113	.024	.028	.030	.034	.043
34	.045	.053	.057	.064	.080	74	.030	.036	.038	.043	.053	114	.024	.028	.030	.034	.042
35	.044	.053	.056	.063	.079	75	.030	.035	.038	.043	.053	115	.024	.028	.030	.034	.042
36	.044	.052	.055	.063	.078	76	.030	.035	.038	.042	.053	116	.024	.029	.030	.034	.042
37	.043	.051	.055	.062	.076	77	.029	.035	.037	.042	.052	117	.024	.028	.030	.034	.042
38	.042	.050	.054	.061	.075	78	.029	.035	.037	.042	.052	118	.023	.029	.030	.034	.042
39	.042	.050	.053	.060	.074	79	.029	.034	.037	.042	.052	119	.023	.028	.030	.033	.041
40	.041	.049	.052	.059	.073	80	.029	.034	.037	.041	.051	120	.023	.029	.029	.033	.041

$$Pm = ((0.03150509\ T^{0.38087957}) - (0.0061 / 1.1^{T}) + (0.0020 / 5^{3T}))/ T$$ where: T = Duration in Hours

P5 = Pm(1.290)   P10 = Pm(1.532)   P15 = Pm(1.637)   P25 = Pm(1.850)   P100 = Pm(2.294)

Where: Pm is the Statistical Mean Annual Precipitation
P5, etc. are the 5-year, etc. Statistical Mean Precipitation

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	UNIT RAINFALL INTENSITY	DATE: FEBRUARY 1987
		FIGURE 8

UNIT RAINFALL INTENSITY FACTOR CHART, Ix PER HOUR

Tc (min)	5 YRS	10 YRS	15 YRS	25 YRS	100YRS	Tc (min)	5 YRS	10 YRS	15 YRS	25 YRS	100YRS	Tc (min)	5 YRS	10 YRS	15 YRS	25 YRS	100YRS
	RECURRENCE INTERVAL						RECURRENCE INTERVAL						RECURRENCE INTERVAL				
121	.023	.027	.029	.033	.041	161	.020	.023	.025	.028	.035	201	.018	.021	.022	.025	.031
122	.023	.027	.029	.033	.041	162	.020	.023	.025	.028	.035	202	.017	.021	.022	.025	.031
123	.023	.027	.029	.033	.041	163	.020	.023	.025	.028	.035	203	.017	.021	.022	.025	.031
124	.023	.027	.029	.033	.041	164	.020	.023	.025	.028	.035	204	.017	.021	.022	.025	.031
125	.023	.027	.029	.033	.040	165	.020	.023	.025	.028	.035	205	.017	.021	.022	.025	.031
126	.023	.027	.029	.032	.040	166	.019	.023	.025	.028	.035	206	.017	.021	.022	.025	.031
127	.023	.027	.029	.032	.040	167	.019	.023	.025	.028	.034	207	.017	.020	.022	.025	.031
128	.023	.027	.028	.032	.040	168	.019	.023	.025	.028	.034	208	.017	.020	.022	.025	.031
129	.022	.027	.028	.032	.040	169	.019	.023	.024	.028	.034	209	.017	.020	.022	.025	.030
130	.022	.026	.028	.032	.040	170	.019	.023	.024	.028	.034	210	.017	.020	.022	.025	.030
131	.022	.026	.028	.032	.039	171	.019	.023	.024	.027	.034	211	.017	.020	.022	.024	.030
132	.022	.026	.028	.032	.039	172	.019	.023	.024	.027	.034	212	.017	.020	.022	.024	.030
133	.022	.026	.028	.031	.039	173	.019	.023	.024	.027	.034	213	.017	.020	.022	.024	.030
134	.022	.026	.028	.031	.039	174	.019	.023	.024	.027	.034	214	.017	.020	.021	.024	.030
135	.022	.026	.028	.031	.039	175	.019	.022	.024	.027	.034	215	.017	.020	.021	.024	.030
136	.022	.026	.028	.031	.039	176	.019	.022	[illegible]	.027	.034	216	.017	.02[illegible]	[illegible]21	.024	.030
137	.022	.026	.027	.031	.038	177	.019	.022	.024	.027	.033	217	.017	.020	.021	.024	.030
138	.022	.026	.027	.031	.038	178	.019	.022	.024	.027	.033	218	.017	.020	.021	.024	.030
139	.021	.025	.027	.031	.038	179	.019	.022	.024	.027	.033	219	.017	.020	.021	.024	.030
140	.021	.025	.027	.031	.038	180	.019	.022	.024	.027	.033	220	.017	.020	.021	.024	.030
141	.021	.025	.027	.031	.038	181	.019	.022	.024	.027	.033	221	.017	.020	.021	.024	.030
142	.021	.025	.027	.030	.038	182	.019	.022	.023	.027	.033	222	.017	.020	.021	.024	.029
143	.021	.025	.027	.030	.038	183	.018	.022	.023	.026	.033	223	.017	.020	.021	.024	.029
144	.021	.025	.027	.030	.037	184	.018	.022	.023	.026	.033	224	.017	.020	.021	.024	.029
145	.021	.025	.027	.030	.037	185	.018	.022	.023	.026	.033	225	.016	.020	.021	.024	.029
146	.021	.025	.026	.030	.037	186	.018	.022	.023	.026	.033	226	.016	.020	.021	.024	.029
147	.021	.025	.026	.030	.037	187	.018	.022	.023	.026	.032	227	.016	.019	.021	.023	.029
148	.021	.025	.026	.030	.037	188	.018	.022	.023	.026	.032	228	.016	.019	.021	.023	.029
149	.021	.025	.026	.030	.037	189	.018	.022	.023	.026	.032	229	.016	.019	.021	.023	.029
150	.021	.024	.026	.029	.037	190	.018	.021	.023	.026	.032	230	.016	.019	.021	.023	.029
151	.020	.024	.026	.029	.036	191	.018	.021	.023	.025	.032	231	.016	.019	.021	.023	.029
152	.020	.024	.026	.029	.036	192	.018	.021	.023	.025	.032	232	.016	.019	.021	.023	.029
153	.020	.024	.026	.029	.036	193	.018	.021	.023	.025	.032	233	.016	.019	.020	.023	.029
154	.020	.024	.026	.029	.036	194	.018	.021	.023	.025	.032	234	.016	.019	.020	.023	.029
155	.020	.024	.026	.029	.036	195	.018	.021	.023	.025	.032	235	.016	.019	.020	.023	.029
156	.020	.024	.026	.029	.036	196	.018	.021	.023	.025	.032	236	.016	.019	.020	.023	.029
157	.020	.024	.025	.029	.036	197	.018	.021	.022	.025	.032	237	.016	.019	.020	.023	.028
158	.020	.024	.025	.029	.036	198	.018	.021	.022	.025	.032	238	.016	.019	.020	.023	.028
159	.020	.024	.025	.029	.035	199	.018	.021	.022	.025	.032	239	.016	.019	.020	.023	.028
160	.020	.024	.025	.028	.035	200	.018	.021	.022	.025	.032	240	.016	.019	.020	.023	.028
												24 HOURS	.0056	.0067	.0072	[illegible]	[illegible]

$$Pm = ((0.03150509\,T^{0.38087957}) - (0.0061 / 1.1) + (0.0020 / 5^{3T}))$$

where: T Duration in Hours

P5 = Pm(1.290) P10 = Pm(1.532) P15 = Pm(1.637) P25 = Pm(1.850)

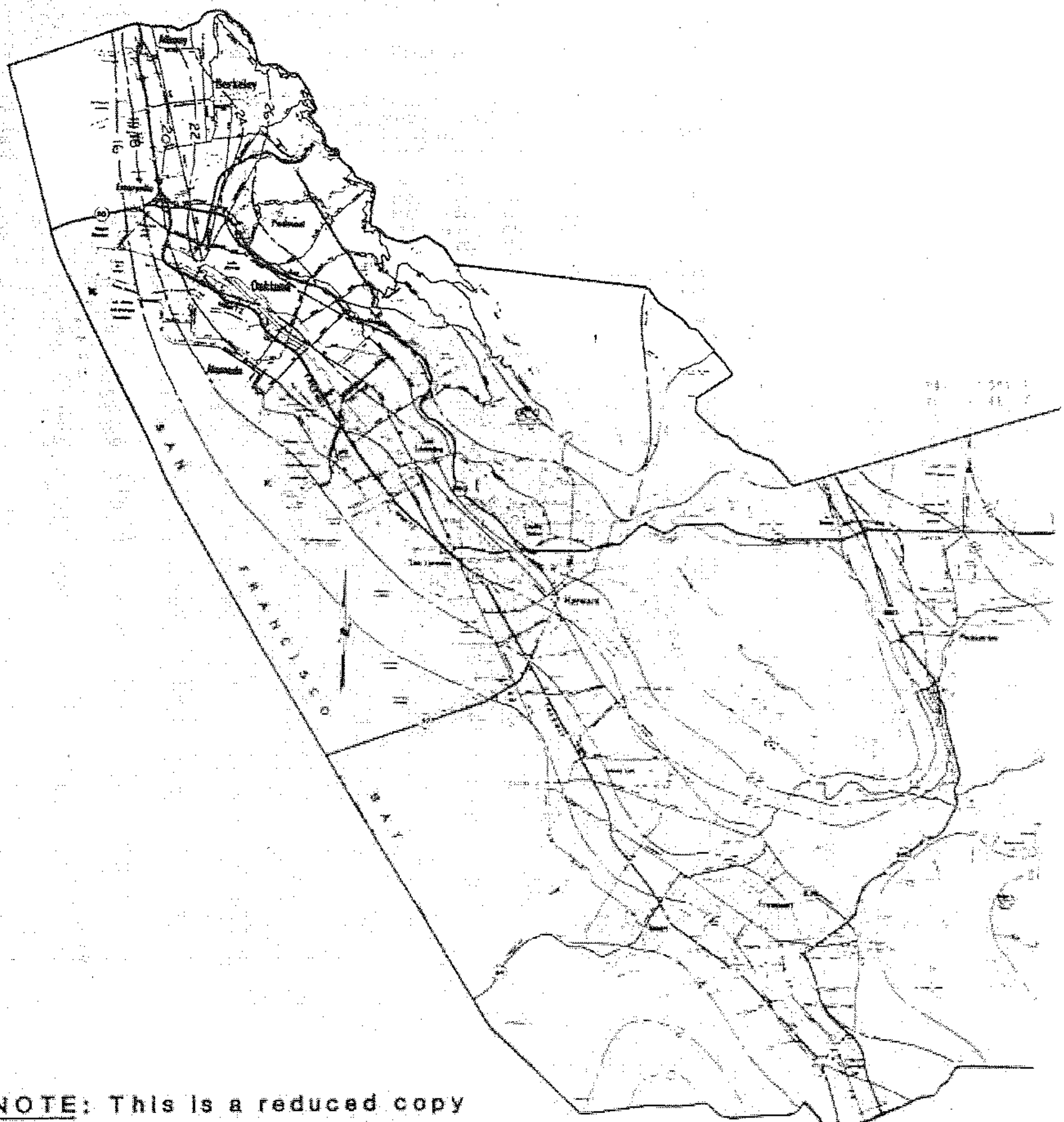
where: Pm is the Statistical Mean Annual Precipitation
P5, etc. are the 5-year, etc. Statistical Mean Precipitation

ALAMEDA COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

UNIT RAINFALL INTENSITY

DATE: FEBRUARY 1987

FIGURE 8



NOTE: This is a reduced copy of drawing MA-180, available at District offices.

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	MEAN ANNUAL PRECIPITATION	DATE: FEBRUARY 1987
		FIGURE 9

RUNOFF FACTOR SLOPE AND INTENSITY ADJUSTMENT CHART PG 1 OF 3

C = Initial Runoff Factor
C+Cs = Runoff Factor + Slope Adjustment
C' = Design Runoff Factor

To determine C' begin with the initial runoff factor C in the upper left of the chart. Draw a line to the right until you meet a ground slope greater than the average ground slope of the incremental drainage area. Next draw a line down until you reach a rainfall intensity greater than your design intensity. Next draw a line to the left to find your design runoff factor C'

	BEGIN BELOW	.20	.21	.22	.23	.24	.25	.26	.27	.28	.29	.30	.31	.32	.33	.34	.35	.36	.37	.38	.39	.40	
												C + Cs											
	.20	2	3	4	5	6	7	9	10	11	13	14	16	17	19	20	22	24	25	27	29	31	S
	.30	----	----	----	----	----	----	----	----	----	----	2	3	5	6	7	9	10	12	14	15	17	L
	.40	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2	O
C	.50	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	next	P
	.60	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	next	E
	.70	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	next	
	.80	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	next	%
	.20	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
	.21	.57	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
	.22	.77	.57	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
	.23	.93	.78	.58	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
	.24	1.07	.94	.78	.58	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
	.25	1.20	1.08	.94	.79	.59	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
C'	.26	1.33	1.21	1.09	.95	.79	.59	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	I
=	.27	1.45	1.34	1.23	1.10	.96	.80	.60	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	N
C	.28	1.58	1.47	1.36	1.24	1.11	.97	.81	.60	.00	----	----	----	----	----	----	----	----	----	----	----	----	T
+	.29	1.70	1.59	1.48	1.37	1.25	1.12	.98	.81	.61	.00	----	----	----	----	----	----	----	----	----	----	----	E
Cs	.30	1.82	1.72	1.61	1.50	1.38	1.26	1.13	.99	.82	.61	.00	----	----	----	----	----	----	----	----	----	----	N
+	.31	1.95	1.84	1.74	1.63	1.51	1.40	1.27	1.14	1.00	.83	.62	.00	----	----	----	----	----	----	----	----	----	S
Ci	.32	2.08	1.97	1.86	1.76	1.65	1.53	1.41	1.29	1.15	1.01	.84	.62	.00	----	----	----	----	----	----	----	----	I
	.33	2.21	2.10	2.00	1.89	1.78	1.66	1.55	1.43	1.30	1.17	1.02	.84	.63	.00	----	----	----	----	----	----	----	T
	.34	2.35	2.24	2.13	2.02	1.91	1.80	1.68	1.57	1.44	1.31	1.18	1.03	.85	.63	.00	----	----	----	----	----	----	Y
	.35	2.49	2.38	2.27	2.16	2.05	1.94	1.82	1.70	1.58	1.46	1.33	1.19	1.04	.86	.64	.00	----	----	----	----	----	
	.36	2.64	2.52	2.41	2.30	2.19	2.08	1.96	1.84	1.73	1.60	1.48	1.34	1.20	1.05	.87	.64	.00	----	----	----	----	I
	.37	2.79	2.68	2.56	2.45	2.34	2.22	2.10	1.99	1.87	1.75	1.62	1.50	1.35	1.22	1.06	.88	.65	.00	----	----	----	N
	.38	2.96	2.84	2.72	2.60	2.49	2.37	2.25	2.14	2.02	1.90	1.77	1.65	1.51	1.38	1.23	1.07	.89	.66	.00	----	----	/
	.39	3.13	3.01	2.89	2.77	2.65	2.53	2.41	2.29	2.17	2.05	1.92	1.80	1.67	1.53	1.39	1.25	1.08	.90	.66	.00	----	H
	.40	3.32	3.19	3.06	2.94	2.82	2.69	2.57	2.45	2.32	2.20	2.08	1.95	1.82	1.69	1.55	1.41	1.26	1.10	.91	.67	.00	R
	.41	3.52	3.38	3.25	3.12	2.99	2.87	2.74	2.61	2.49	2.36	2.24	2.11	1.98	1.85	1.71	1.58	1.43	1.28	1.11	.92	.68	
	.42	3.73	3.59	3.45	3.32	3.18	3.05	2.92	2.79	2.66	2.53	2.40	2.27	2.14	2.01	1.88	1.74	1.60	1.45	1.29	1.12	.93	
	.43	3.96	3.81	3.67	3.53	3.39	3.25	3.11	2.98	2.84	2.71	2.58	2.44	2.31	2.18	2.04	1.90	1.77	1.62	1.47	1.31	1.14	
	.44	4.21	4.06	3.90	3.75	3.61	3.46	3.32	3.18	3.04	2.90	2.76	2.62	2.49	2.35	2.21	2.08	1.94	1.79	1.65	1.49	1.33	
	.45	4.49	4.32	4.16	4.00	3.84	3.69	3.54	3.39	3.25	3.10	2.96	2.82	2.67	2.53	2.39	2.25	2.11	1.97	1.82	1.67	1.51	
	.46	4.79	4.61	4.44	4.27	4.10	3.94	3.78	3.62	3.47	3.32	3.17	3.02	2.87	2.73	2.58	2.44	2.29	2.15	2.00	1.85	1.70	
	.47	5.12	4.93	4.74	4.56	4.39	4.21	4.04	3.88	3.71	3.55	3.40	3.24	3.09	2.94	2.79	2.64	2.49	2.34	2.19	2.04	1.88	
	.48	5.49	5.28	5.08	4.89	4.70	4.51	4.33	4.15	3.98	3.81	3.64	3.48	3.32	3.16	3.00	2.85	2.69	2.54	2.39	2.23	2.08	
	.49	5.90	5.68	5.46	5.25	5.04	4.84	4.65	4.46	4.27	4.09	3.91	3.74	3.57	3.40	3.24	3.07	2.91	2.75	2.59	2.43	2.28	
	.50	6.37	6.13	5.89	5.66	5.43	5.22	5.00	4.80	4.60	4.40	4.21	4.03	3.84	3.67	3.49	3.32	3.15	2.98	2.82	2.65	2.49	
	.51	6.90	6.63	6.37	6.12	5.87	5.63	5.40	5.18	4.96	4.75	4.54	4.34	4.15	3.96	3.77	3.59	3.41	3.23	3.06	2.88	2.71	
	.52	7.51	7.21	6.92	6.64	6.37	6.11	5.86	5.61	5.37	5.14	4.92	4.70	4.49	4.28	4.08	3.88	3.69	3.50	3.32	3.14	2.96	
	.53	8.23	7.88	7.56	7.25	6.94	6.65	6.37	6.10	5.84	5.58	5.34	5.10	4.87	4.64	4.42	4.21	4.01	3.80	3.61	3.41	3.22	
	.54	9.05	8.67	8.30	7.95	7.61	7.28	6.97	6.66	6.37	6.09	5.82	5.55	5.30	5.05	4.81	4.58	4.36	4.14	3.93	3.72	3.52	
	.55	****	9.59	9.17	8.77	8.39	8.02	7.66	7.32	6.99	6.68	6.37	6.08	5.80	5.52	5.26	5.00	4.76	4.52	4.29	4.06	3.84	
	.56	****	****	****	9.75	9.31	8.89	8.48	8.09	7.72	7.36	7.02	6.69	6.37	6.07	5.77	5.49	5.22	4.95	4.70	4.45	4.21	
	.57	****	****	****	****	****	9.92	9.46	9.01	8.58	8.18	7.78	7.41	7.05	6.70	6.37	6.05	5.75	5.45	5.17	4.90	4.63	
	.58	****	****	****	****	****	****	****	****	9.62	9.15	8.70	8.27	7.85	7.46	7.08	6.72	6.37	6.04	5.72	5.41	5.12	
	.59	****	****	****	****	****	****	****	****	****	****	9.81	9.31	8.83	8.37	7.93	7.51	7.12	6.74	6.37	6.02	5.69	
	.60	****	****	****	****	****	****	****	****	****	****	****	****	****	9.48	8.97	8.48	8.02	7.58	7.15	6.75	6.37	
	.61	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	9.67	9.13	8.61	8.11	7.64	7.20	
	.62	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	9.90	9.31	8.75	8.22	
	.63	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	9.51	
	.64	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

RUNOFF FACTOR ADJUSTMENT

DATE: FEBRUARY 1987

FIGURE 10

RUNOFF FACTOR SLOPE AND INTENSITY ADJUSTMENT CHART PG 2 OF 3

C = Initial Runoff Factor
C+Cs = Runoff Factor + Slope Adjustment
C` = Design Runoff Factor

To determine C` begin with the initial runoff factor C in the upper left of the chart. Draw a line to the right until you meet a ground slope greater than the average ground slope of the incremental drainage area. Next draw a line down until you reach a rainfall intensity greater than your design intensity. Next draw a line to the left to find your design runoff factor C`

	BEGIN BELOW	.40	.41	.42	.43	.44	.45	.46	.47	.48	.49	.50	.51	.52	.53	.54	.55	.56	.57	.58	.59	.60	
												C + Cs											
	.20	31	33	35	37	39	41	43	45	----	----	----	----	----	----	----	----	----	----	----	----	end	S
	.30	17	19	21	23	25	27	29	32	34	36	39	41	44	45	----	----	----	----	----	----	end	L
	.40	2	4	5	7	9	11	13	15	17	20	22	25	27	30	33	36	39	42	45	----	end	O
C	.50	----	----	----	----	----	----	----	----	----	----	3	4	6	9	11	14	17	20	24	27	31	P
	.60	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2	E
	.70	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	next	
	.80	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	next	%

		.40	.41	.42	.43	.44	.45	.46	.47	.48	.49	.50	.51	.52	.53	.54	.55	.56	.57	.58	.59	.60	
	.40	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.41	.68	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.42	.93	.69	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.43	1.14	.94	.69	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.44	1.33	1.15	.95	.70	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.45	1.51	1.35	1.17	.97	.71	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
C`	.46	1.70	1.54	1.37	1.19	.98	.72	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	I
=	.47	1.88	1.73	1.56	1.39	1.20	.99	.73	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	N
C	.48	2.08	1.92	1.76	1.59	1.41	1.22	1.01	.74	.00	----	----	----	----	----	----	----	----	----	----	----	----	T
+	.49	2.28	2.12	1.95	1.79	1.62	1.44	1.26	1.02	.75	.00	----	----	----	----	----	----	----	----	----	----	----	E
Cs	.50	2.49	2.32	2.16	1.99	1.82	1.65	1.46	1.26	1.04	.76	.00	----	----	----	----	----	----	----	----	----	----	N
+	.51	2.71	2.54	2.37	2.20	2.03	1.86	1.68	1.49	1.28	1.05	.72	.00	----	----	----	----	----	----	----	----	----	S
Ci	.52	2.96	2.78	2.60	2.43	2.25	2.08	1.90	1.71	1.51	1.31	1.07	.78	.00	----	----	----	----	----	----	----	----	I
	.53	3.22	3.04	2.85	2.67	2.49	2.31	2.12	1.94	1.74	1.54	1.33	1.09	.79	.00	----	----	----	----	----	----	----	T
	.54	3.52	3.32	3.12	2.93	2.74	2.55	2.36	2.17	1.98	1.78	1.58	1.36	1.11	.81	.00	----	----	----	----	----	----	Y
	.55	3.84	3.63	3.42	3.22	3.01	2.82	2.62	2.42	2.22	2.03	1.82	1.61	1.38	1.13	.82	.00	----	----	----	----	----	
	.56	4.21	3.98	3.75	3.53	3.32	3.11	2.90	2.69	2.49	2.28	2.08	1.86	1.65	1.41	1.15	.84	.00	----	----	----	----	I
	.57	4.63	4.38	4.13	3.89	3.66	3.43	3.21	2.99	2.77	2.56	2.35	2.13	1.91	1.68	1.44	1.18	.85	.00	----	----	----	N
	.58	5.12	4.84	4.56	4.30	4.04	3.79	3.55	3.32	3.09	2.86	2.64	2.41	2.19	1.96	1.73	1.48	1.20	.87	.00	----	----	/
	.59	5.69	5.37	5.06	4.77	4.49	4.21	3.95	3.69	3.44	3.20	2.96	2.72	2.49	2.25	2.02	1.77	1.51	1.23	.89	.00	----	H
	.60	6.37	6.01	5.66	5.32	5.00	4.70	4.40	4.12	3.84	3.58	3.32	3.06	2.82	2.57	2.32	2.08	1.82	1.55	1.26	.92	.00	R
	.61	7.20	6.77	6.37	5.99	5.62	5.27	4.94	4.62	4.31	4.02	3.73	3.45	3.18	2.92	2.66	2.40	2.14	1.88	1.63	1.29	.93	
	.62	8.22	7.72	7.25	6.80	6.37	5.97	5.58	5.22	4.87	4.53	4.21	3.90	3.61	3.32	3.04	2.76	2.49	2.21	1.94	1.65	1.33	
	.63	9.51	8.91	8.34	7.81	7.30	6.82	6.37	5.94	5.54	5.15	4.79	4.44	4.10	3.78	3.47	3.17	2.87	2.58	2.29	2.00	1.70	
	.64	****	****	9.75	9.09	8.48	7.90	7.36	6.85	6.37	5.92	5.49	5.08	4.70	4.33	3.98	3.64	3.32	3.00	2.69	2.39	2.08	
	.65	****	****	****	****	****	9.31	8.64	8.02	7.43	6.89	6.37	5.89	5.43	5.00	4.60	4.21	3.84	3.49	3.15	2.82	2.49	
	.66	****	****	****	****	****	****	****	9.55	8.83	8.15	7.51	6.92	6.37	5.86	5.37	4.92	4.49	4.08	3.69	3.32	2.96	
	.67	****	****	****	****	****	****	****	****	****	9.85	9.05	8.30	7.61	6.97	6.37	5.82	5.30	4.81	4.36	3.93	3.52	
	.68	****	****	****	****	****	****	****	****	****	****	****	****	9.31	8.48	7.72	7.02	6.37	5.77	5.22	4.70	4.21	
	.69	****	****	****	****	****	****	****	****	****	****	****	****	****	****	9.62	8.70	7.85	7.08	6.37	5.72	5.12	
	.70	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	8.97	8.02	7.15	6.37	
	.71	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	9.31	8.22	
	.72	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
	.73	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
	.74	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
	.75	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
	.76	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
	.77	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
	.78	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
	.79	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
	.80	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	RUNOFF FACTOR ADJUSTMENT	DATE: FEBRUARY 1987
		FIGURE 10

RUNOFF FACTOR SLOPE AND INTENSITY ADJUSTMENT CHART PG 3 OF 3

C = Initial Runoff Factor
C+Cs = Runoff Factor + Slope Adjustment
C` = Design Runoff Factor

To determine C` begin with the initial runoff factor C in the upper left of the chart. Draw a line to the right until you meet a ground slope greater than the average ground slope of the incremental drainage area. Next draw a line down until you reach a rainfall intensity greater than your design intensity. Next draw a line to the left to find your design runoff factor C`

	BEGIN											C + Cs											
	BELOW	.60	.61	.62	.63	.64	.65	.66	.67	.68	.69	.70	.71	.72	.73	.74	.75	.76	.77	.78	.79	.80	
	.20	45	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----		
	.30	45	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	end	S
	.40	45	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	end	L
C	.50	31	35	39	43	45	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	end	O
	.60	2	5	9	13	17	22	27	33	39	45	----	----	----	----	----	----	----	----	----	----	end	P
	.70	----	----	----	----	----	----	----	----	----	----	2	9	17	27	39	45	----	----	----	----	end	E
	.80	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	end	
																						2	%
	.60	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.61	.93	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.62	1.33	.95	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.63	1.70	1.37	.98	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.64	2.08	1.76	1.41	1.01	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
	.65	2.49	2.16	1.82	1.46	1.04	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
C`	.66	2.96	2.60	2.25	1.90	1.51	1.07	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	
=	.67	3.52	3.12	2.74	2.36	1.90	1.58	1.11	.00	----	----	----	----	----	----	----	----	----	----	----	----	----	I
C	.68	4.21	3.75	3.32	2.90	2.49	2.08	1.65	1.15	.00	----	----	----	----	----	----	----	----	----	----	----	----	N
+	.69	5.12	4.56	4.04	3.55	3.09	2.64	2.19	1.73	1.20	.00	----	----	----	----	----	----	----	----	----	----	----	T
Cs	.70	6.37	5.66	5.00	4.40	3.84	3.32	2.82	2.32	1.82	1.26	.00	----	----	----	----	----	----	----	----	----	----	E
+	.71	8.22	7.25	6.37	5.58	4.87	4.21	3.61	3.04	2.49	1.94	1.33	.00	----	----	----	----	----	----	----	----	----	N
Ci	.72	****	9.75	8.48	7.36	6.37	5.49	4.70	3.98	3.32	2.69	2.08	1.41	.00	----	----	----	----	----	----	----	----	S
	.73	****	****	****	****	8.83	7.51	6.37	5.37	4.49	3.69	2.96	2.25	1.52	.00	----	----	----	----	----	----	----	I
	.74	****	****	****	****	****	****	9.31	7.72	6.37	5.22	4.21	3.32	2.49	1.65	.00	----	----	----	----	----	----	T
	.75	****	****	****	****	****	****	****	****	****	8.02	6.37	5.00	3.84	2.82	1.82	.00	----	----	----	----	----	Y
	.76	****	****	****	****	****	****	****	****	****	****	****	8.48	6.37	4.70	3.32	2.08	.00	----	----	----	----	
	.77	****	****	****	****	****	****	****	****	****	****	****	****	****	9.31	6.37	4.21	2.49	.00	----	----	----	(
	.78	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	6.37	3.32	.00	----	----	N
	.79	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	5.37	.00	----	/
	.80	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	.00	H
																							R

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	RUNOFF FACTOR ADJUSTMENT	DATE: FEBRUARY 1987
		FIGURE 10

TIME [hrs.]	RAINFALL RATIO Px/P24 (inches/inches)
.0	.0000
.5	.0135
1.0	.0251
1.5	.0382
2.0	.0518
2.5	.0660
3.0	.0810
3.5	.0967
4.0	.1131
4.5	.1304
5.0	.1491
5.5	.1690
6.0	.1903
6.5	.2135
7.0	.2389
7.5	.2675
8.0	.3001
8.5	.3385
9.0	.3862
9.5	.4570
10.0	.5806
10.5	.6975
11.0	.7304
11.5	.7552
12.0	.7760
12.5	.7935
13.0	.8093
13.5	.8246
14.0	.8379
14.5	.8502
15.0	.8616
15.5	.8724
16.0	.8826
16.5	.8923
17.0	.9016
17.5	.9104
18.0	.9188
18.5	.9269
19.0	.9347
19.5	.9422
20.0	.9494
20.5	.9565
21.0	.9633
21.5	.9698
22.0	.9762
22.5	.9824
23.0	.9884
23.5	.9943
24.0	1.0000

NOTE:

The ordinates in this figure are for the Alameda County Type I Rainfall Distribution beginning with time t = 0 and increasing in half-hour increments. This Distribution is based on the SCS Type I, 24 hour temporal rainfall distribution. See Reference 1.

This distribution shall be used to calculate design flows when using the unit hydrograph method.

MASS PRECIPITATION VALUES
24-HOUR STORM:

Frequency	Mass Precipitation Value
10 yr.	0.1608
15 yr.	0.1728
25 yr.	0.1944
100 yr.	0.2411

Precipitation -
(Mass Precip. Value) x
(Mean Annual Precipitation)

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

ALAMEDA COUNTY TYPE I STORM DIST.

DATE: SEPTEMBER 1988

FIGURE 11

DATUM PLANES

ON THESE DATUM PLANES 0.00 IS ABOVE MEAN SEA LEVEL THE NUMBER OF FEET INDICATED.

8.616		City of San Francisco (City Engineer 12/10/64)
5.730	*	Highest Tide at Pt. San Quentin Estimated (State Chart 11/19/51)
5.470	*	Highest Tide at Pt. Richmond Estimated (State Chart 11/19/51)
5.200	*	Highest Tide at Presidio 12/24/40 (State Chart 11/19/51)
3.410		City of Alameda (City Engineer 1/7/65)
3.26		Emeryville
3.17		Berkeley
3.00		City of Oakland (City Engineer 12/10/64)
2.87	*	M.H.H.W. at Pt. Richmond (State Chart 11/19/51)
2.80		San Leandro (Prior to 1960)
2.65	*	S.P.R.R. Coast Division (2.61 M.H.H.W. at Presidio State Chart 11/19/51)
2.03	*	M.H.H.W. at Presidio (State Chart 11/19/51)
VARIES		EBMUD Mokelumne Aqueduct (Varies - See Published Lists)

0.00 USC&GS Mean Sea Level Datum of 1929:

- Alameda County
- Alameda County Flood Control & Conservation District
- Albany
- Bay Area Rapid Transit District (Verified by R.M. Towill Inc.)
- California Division of Highways Dist. IV (Since 1956)
- Central Contra Costa Sanitary District
- Concord
- Contra Costa County
- Contra Costa County Flood Control
- E.B.M.U.D.
- El Cerrito (Ord. #7100)
- Hayward
- Richmond
- Richmond - San Rafael Bridge
- San Leandro (Since 1960)
- San Pablo
- Webster St. Tube

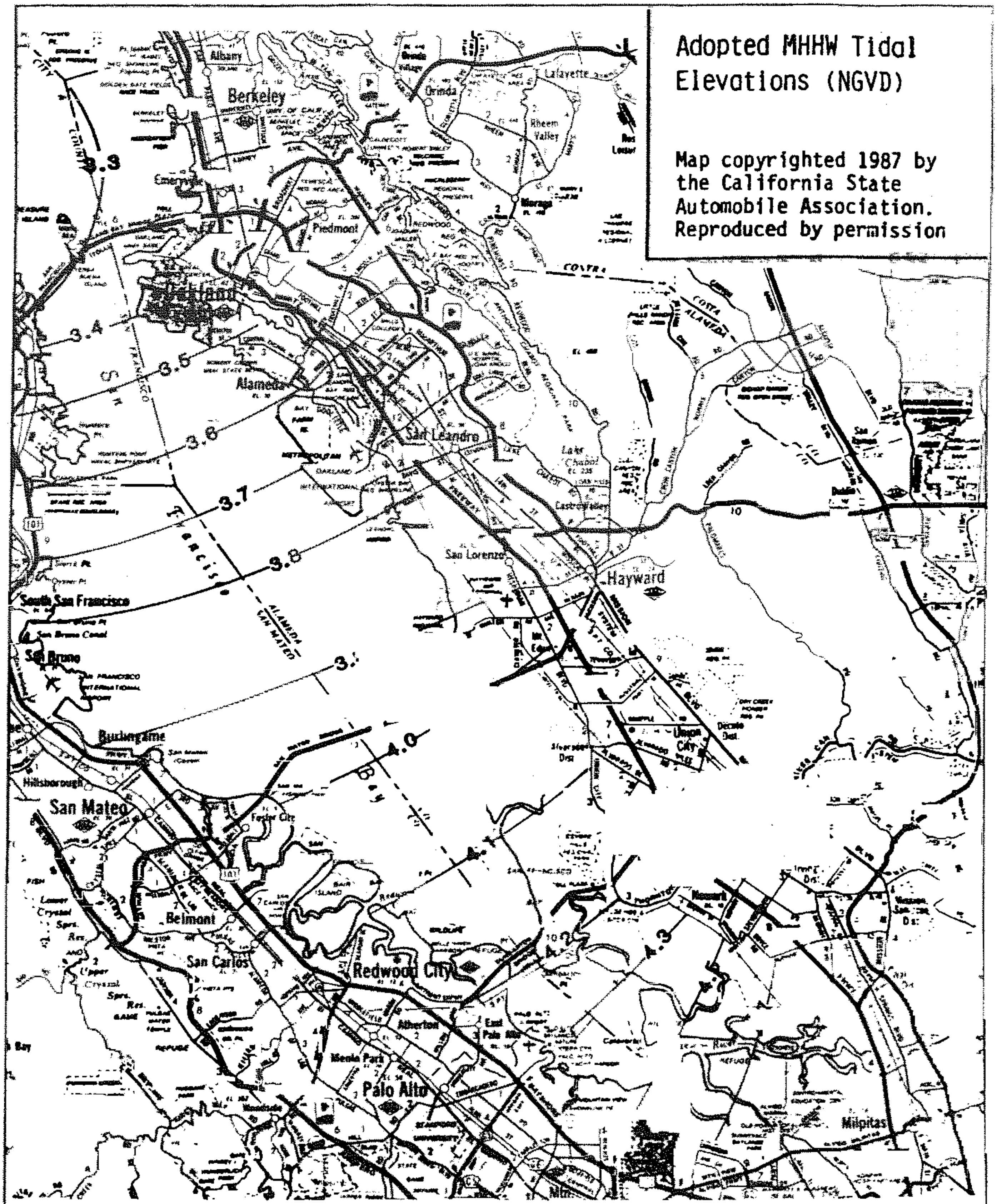
ON THESE DATUM PLANES 0.00 IS BELOW MEAN SEA LEVEL THE NUMBER OF FEET INDICATED.

-1.44		San Pablo Reservoir (At San Pablo Dam)
-1.51		San Pablo Reservoir (At San Pablo Filter Plant)
-2.171		Richmond (Prior to 1962)
-2.77	*	M.L.L.W. Pt. San Quentin (State Chart 11/19/51)
-2.83	*	M.L.L.W. Pt. San Pablo (State Chart 11/19/51)
-3.03	*	M.L.L.W. Pt. Richmond (State Chart 11/19/51)
-3.10	*	S.F.O.B.B. & Parallel Bridge, M.L.L.W. at Presidio (State Chart 11/19/51)
-3.20		Port of Oakland (Since 1959)
-3.817	*	C.P. Ry. (Western Div. - East Bay) (State Chart 11/19/51)
-4.25	*	State Hwy. #1, S.F.O.B.B. East Bay Approaches (State Chart 11/19/51)
-5.50	*	Lowest Tide Presidio (State & E.B.M.U.D.)
-8.600	*	Bottom Presidio Staff Gage (State Charts)
-97.011	*	Posey Tube Datum
-100.00		E.B.M.U.D. Water Pollution Control Div.

NOTES:

1. An elevation based on a special datum may be converted to an elevation based on USC&GS mean sea level datum by adding the indicated difference.
2. All elevations are vertical distances above or below a level surface. This surface or level datum is assumed to remain at a fixed elevation whereas the record elevation of bench marks may vary due to discrepancies, movement of marks, and readjustment of level lines. For these reasons a conversion chart is limited as to accuracy and on any project where a dependable relationship of level data is required a field check should be made.
3. * Information obtained in 1959 or earlier and not verified for this edition.

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	**BAY AREA DATUM PLANES**	DATE: **FEBRUARY 1987**
		FIGURE 12



Adopted MHHW Tidal Elevations (NGVD)

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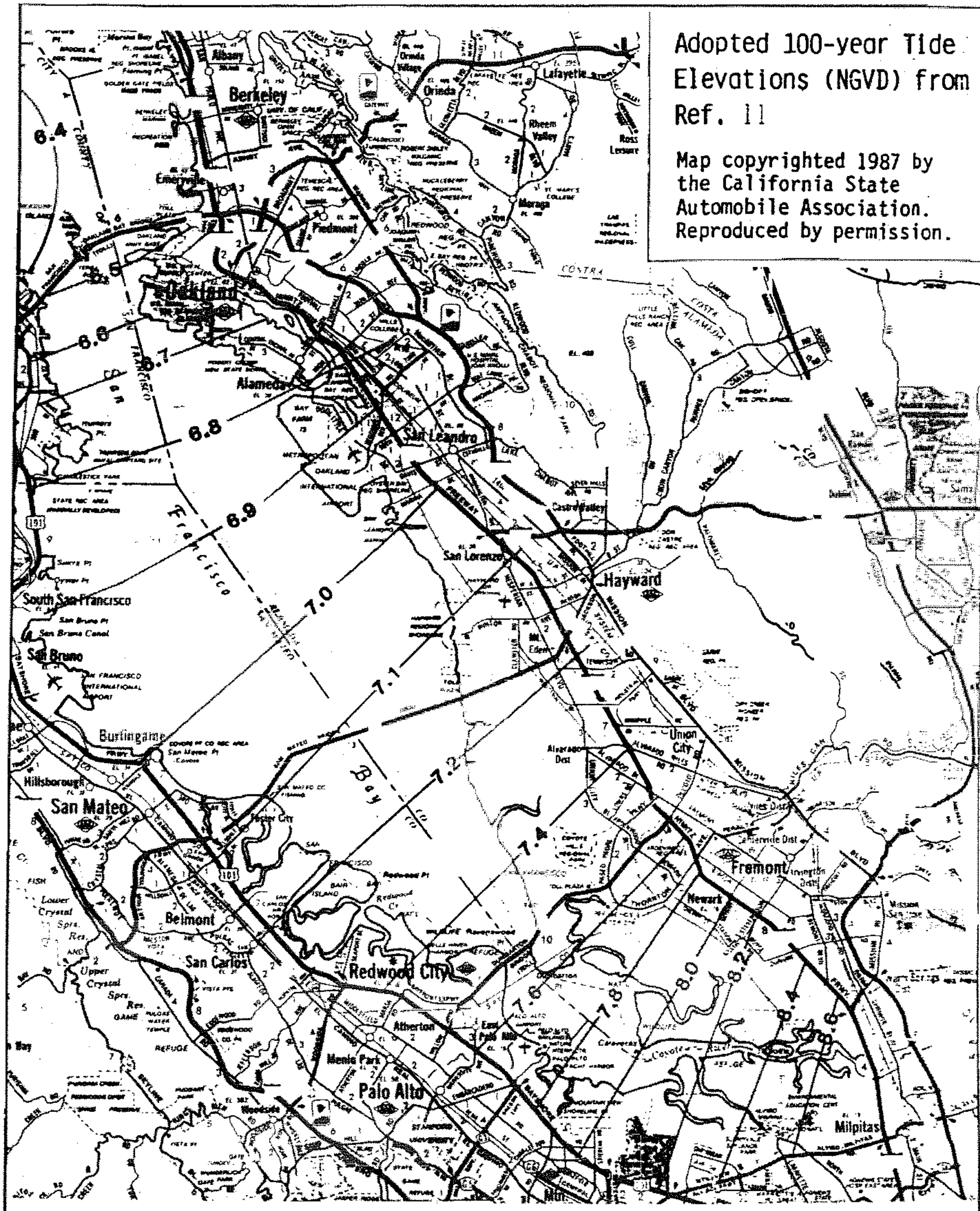
ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	TIDAL SUMMARY	DATE: FEBRUARY 1987
		FIGURE 13



Adopted 100-year Tide Elevations (NGVD) from Ref. 11

Map copyrighted 1987 by the California State Automobile Association. Reproduced by permission.

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	TIDAL SUMMARY	DATE: FEBRUARY 1987
		FIGURE 13

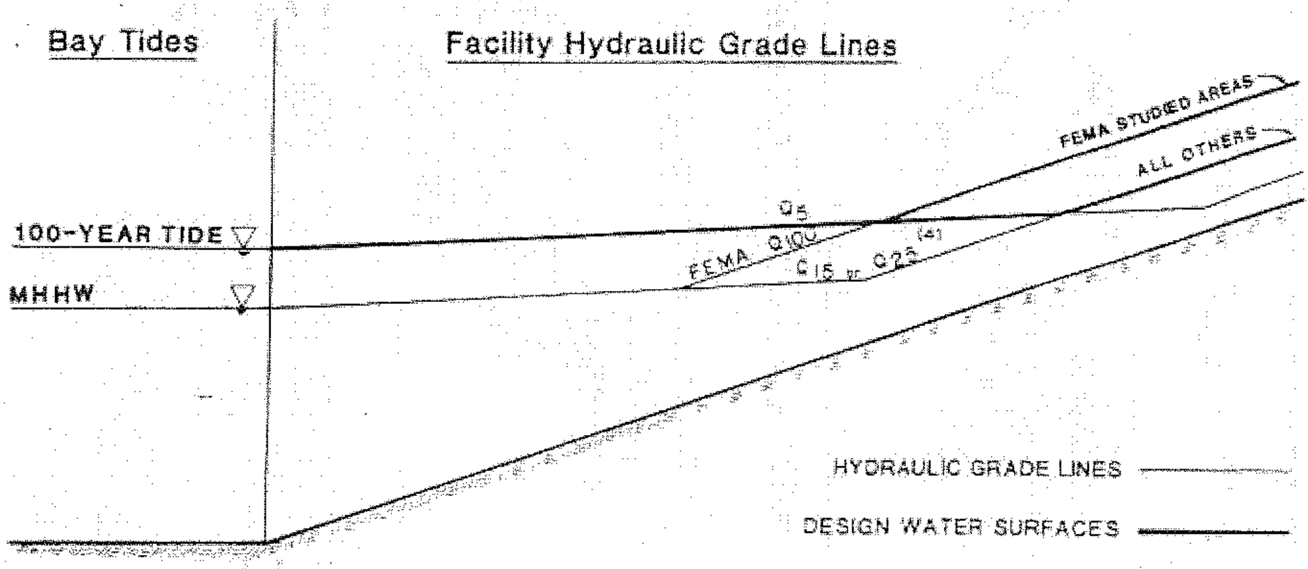
TIDAL SUMMARY - BACKROUND DATA

STATION NO.	DESCRIPTION	TIDAL ELEVATION - NGVD MHHW	100-YR
4816	Berkeley	3.3	6.4
4779	Matson Wharf	3.4	6.3
4764	Oakland Inner Harbor	3.4	6.5
4750	Alameda Naval Air Sta.	3.4	6.7
4746	Park Street Bridge	3.3	6.4
4711	Oakland Airport	3.7	6.8
4688	San Leandro Channel	3.8	6.9
4637	S. Mateo Br, East end	3.9	7.0
4509	Dumbarton Br	4.2	7.5
4506	Newark Slough	4.4	7.5
4519	Mowry Slough	4.3	7.4
4575	Coyote Ck/Alviso Slough	4.6	8.1

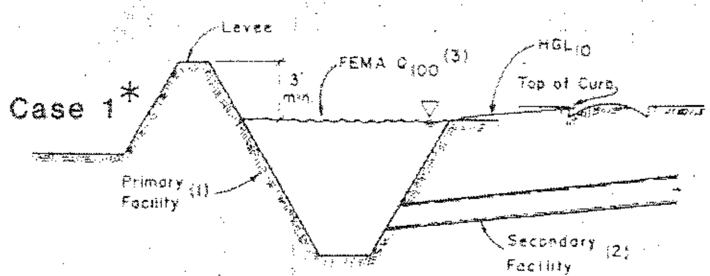
Source: Refenence No. 11.
The figures above are given for backgound information. The values to be used in design are to be found on the contour maps of San Francisco Bay, Pages 40 and 41 for the Mean Higher High Water (MHHW) and the 100-Year Tides, respectively.

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	TIDAL SUMMARY	DATE: FEBRUARY 1987 FIGURE 13

PRIMARY FACILITIES

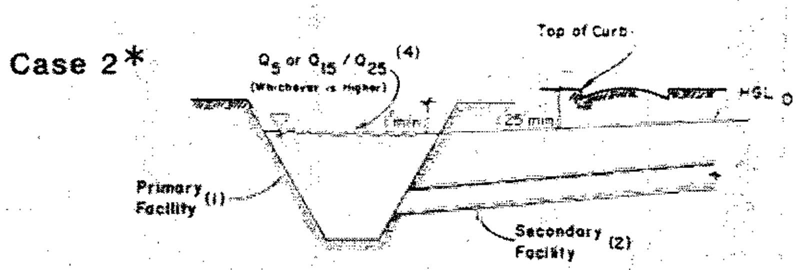


SECONDARY FACILITIES



NOTES

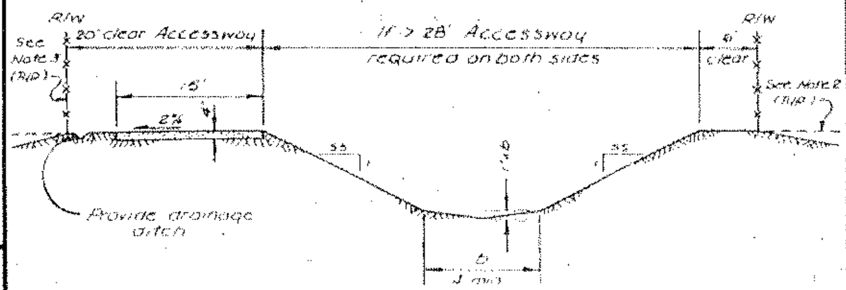
1. [illegible] facilities have a drainage area between [illegible] acres and [illegible] square miles.
2. Secondary facilities have a drainage area less than [illegible] acres.
3. Primary facilities shall contain the FEMA Q(100) with adequate freeboard within FEMA study areas.
4. Use Q25 for Zone No. [illegible] only.
5. For freeboard requirements, see Paragraph 2.3
6. Street system or alternative shall carry storm water in excess of the design flows from the primary facility.



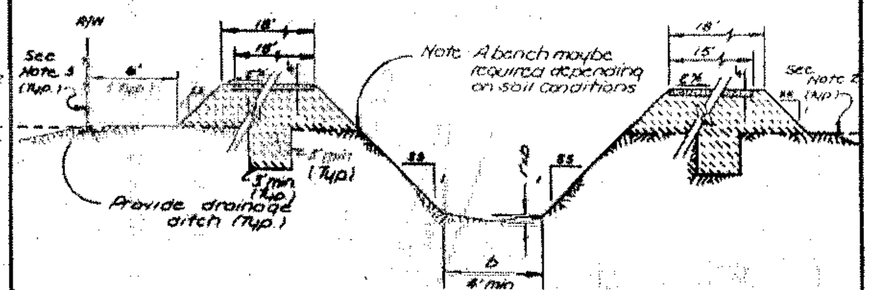
* USE THE HIGHER OF EITHER CASE 1 OR CASE 2

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	DESIGN WATER SURFACE SUMMARY	DATE: FEBRUARY 1987
		FIGURE 14

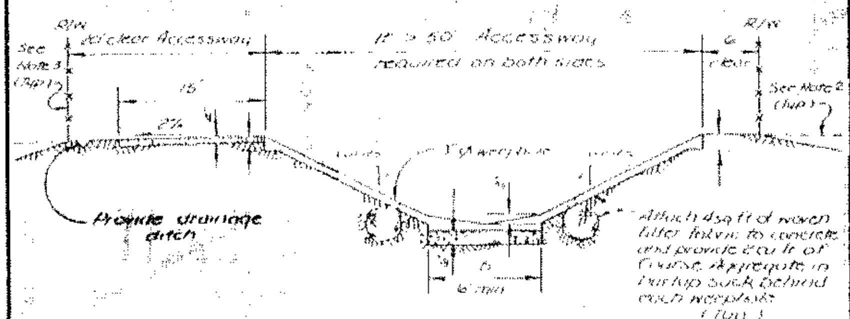
(1) Non-Leveed Earth Channel



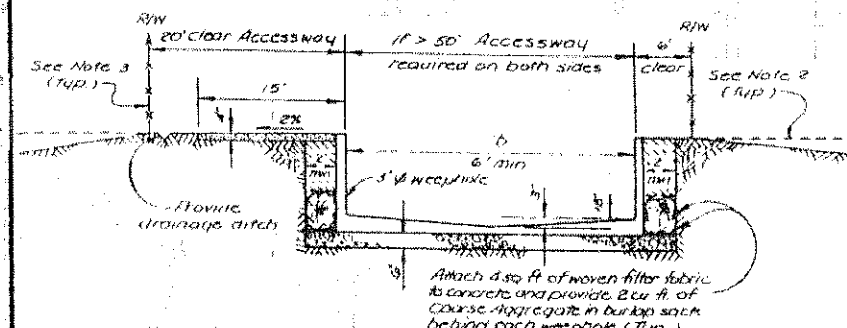
(2) Leveed Earth Channel



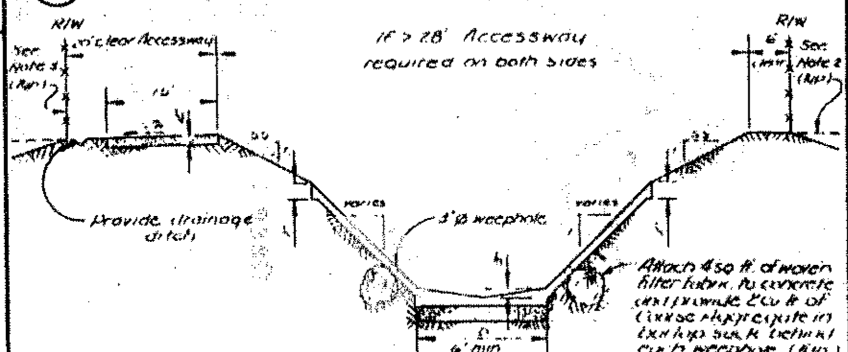
(3) Shallow Concrete Lined Trapezoidal Channel



(4) Shallow Concrete Lined Flume Channel



(5) Deep Concrete Lined Trapezoidal or Flume Channel



Notes

1. Prior to using these standards it is desirable in all cases for design engineers to discuss with Flood Control District the adoption of these standards for particular field conditions.
2. Adjoining ground shall be graded to drain away from the channel.
3. Install standard 6 foot high vinyl-clad chain link fence 6 inches inside R/W.
4. Graded channel slope for earth sections (SS) shall not be steeper than 2:1 unless specifically approved by the Deputy Director of Public Works - Design.
5. All construction shall conform to the Standard Specifications of the Department of Transportation State of California.

Legend

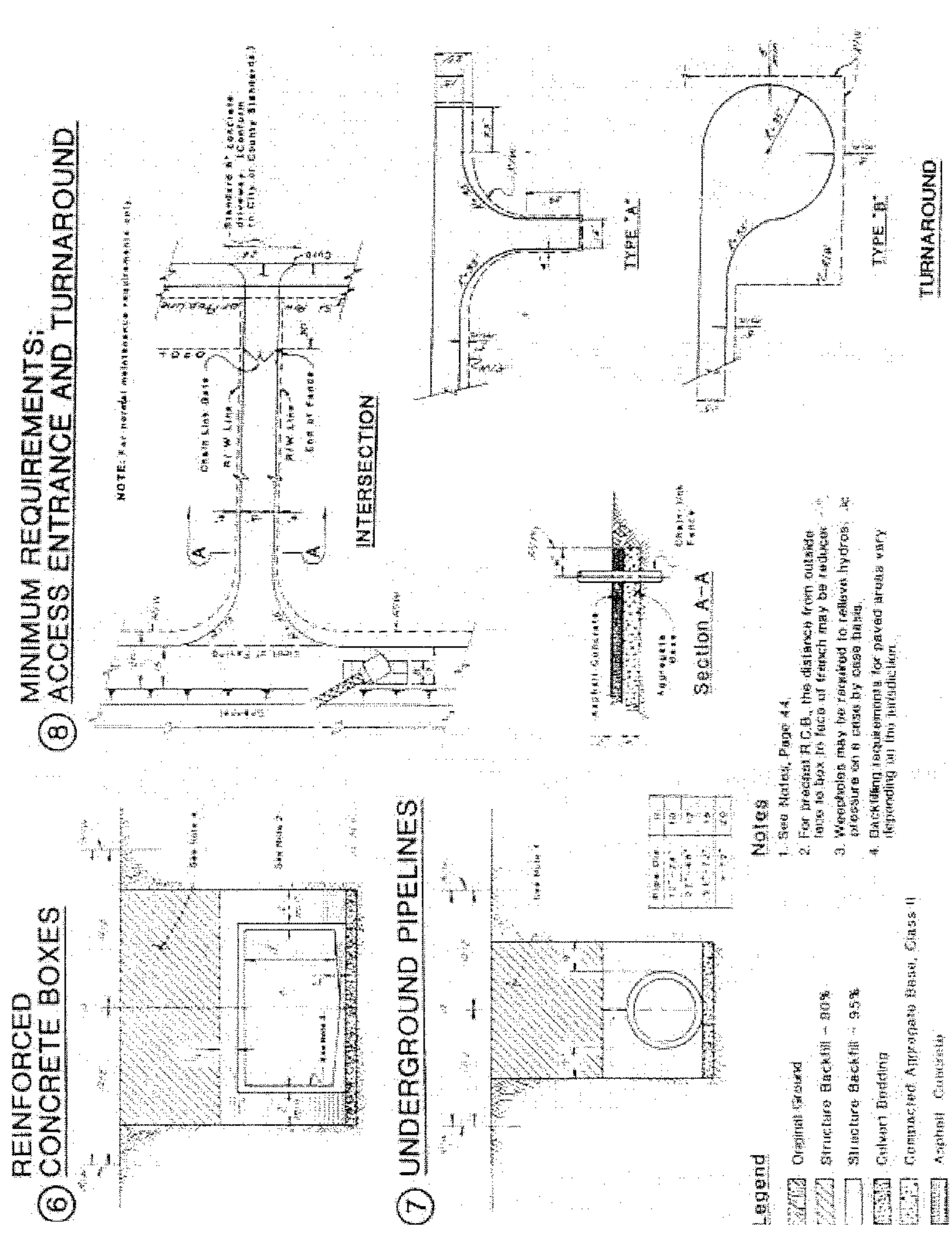
- Undisturbed Earth
- Coarse Aggregate
- Embankment Material
- Compacted Aggregate Base
- Class II Permeable Backfill

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

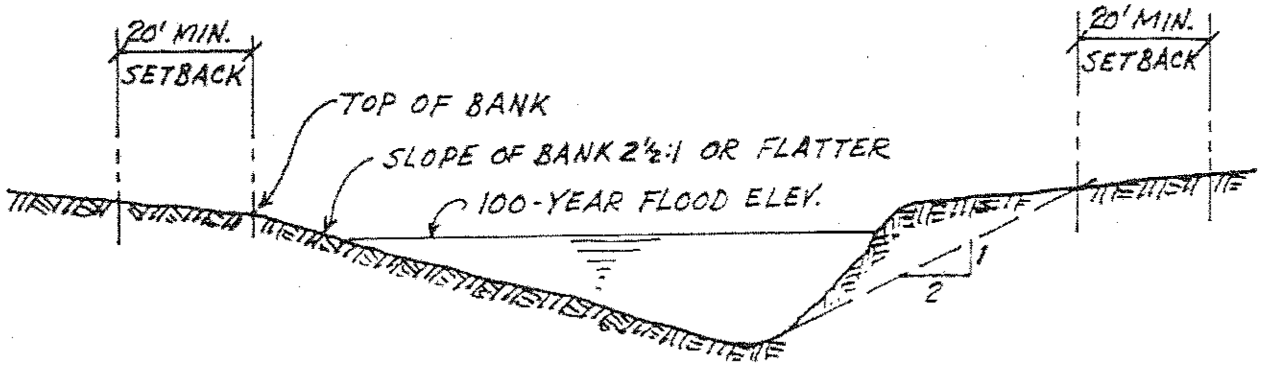
DESIGN GUIDELINES

DATE: FEBRUARY 1987

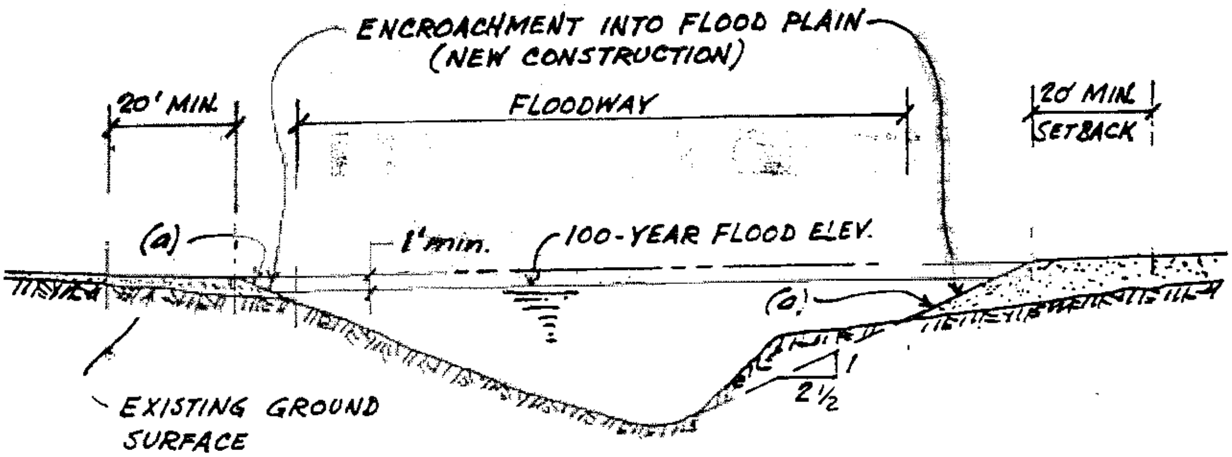
FIGURE 15



ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	DESIGN GUIDELINES	DATE: FEBRUARY 1987 FIGURE 15



SECTION A - APPLIES WHEN 100-YEAR STORM IS CONTAINED WITHIN EXISTING FACILITY



(a) Slope of bank shall be 2-1/2 horizontal to 1 vertical or flatter, as determined by the Deputy Director - Design.

SECTION B - APPLIES WHEN THE EXISTING FACILITY IS LARGE ENOUGH TO ACCOMODATE SIDE ENCROACHMENT.

NOTE: For details concerning setback criteria, see Ref. 10.

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	SETBACK CRITERIA	DATE: FEBRUARY 1987 / FIGURE 16

Tract/Parcel Map No.__________
Review Deposit $__________

DRAINAGE REVIEW CHECK LIST

The improvement plans accompanying this check list are submitted for your review. They have been prepared by me or under my direction and checked for conformance with the approved tentative map (or plan), the conditions of approval & the Alameda County Flood Control and Water Conservation District "Hydrology & Hydraulics Criteria Summary."

________________________ ________
Engineer's Signature Date

____
Engineering Firm-Address

____
Contact Person, Title & Phone No.

____
Developer

____
Address

____
Contact Person, Title & Phone No.

____
Assessor's Parcel No.

REVIEW SUBMITTAL

2 Complete Sets of Plans
1 Set of Hydrology and Hydraulic Calculations
1 Copy of Hydrology Map
1 Copy of Structural Calculations
Plan Review Deposit

INSTRUCTIONS: Place a check mark to indicate you comply or N/A to indicate not applicable next to each item. Any requests for exceptions shall be made in writing & attached herewith.

Hydrology-Hydraulics

____1. Contour maps - continuing for 100'± beyond property boundaries.
____2. Drainage area maps (40 scale or larger) shall show on and off-site topography, points of concentration and sub-areas with designations that are matched with the hydrology calculations. The drainage area map must show, at scale, all areas tributary to the project site.
____3. Provide hydrology & hydraulic calculations that follow the latest edition of the "Hydrology & Hydraulics Criteria Summary" prepared by ACFC & WCD; hereinafter referred to as Criteria Summary.
____4. Freeboard in channels, structures, and pipes shall comply with the Criteria Summary.
____5. Calculations are to include EGL, HGL, FL, Q, A, Sf, Hv, freeboard at structures, losses, hydraulic control assumptions, super or subcritical flow.
____6. After the hydraulic calculations have been approved, delineate EGL, HGL, FL, Q, and So on the profile print.
____7. All starting water surface elevations are to be adequately verified and documented. When computing beginning HGL in natural watercourses and no obvious point of control is available, begin upstream or downstream 500' as control dictates to point in question.
____8. Improvement Plans are to be on standard 24"x36" sheets.
____9. Grading Plans must clearly show that runoff is being picked up from adjacent uphill properties and is not being allowed to flow onto adjacent downhill properties.
____10. Delineate areas within FEMA flood hazard zones.

Easements

____11. Show off-site drainage improvements (plan & profile) and easements.
____12. Indicate storm drain easement widths.
____13. Submit sufficient X-sections to verify easement widths for open channels.
____14. ACFC & WCD maintenance roads are to be improved to District standards.
____15. Minimum center-line radii for ACFC & WCD maintenance roads is 43'.
____16. Show fences and gates along ACFC & WCD easements and rights of way.

Structures

____17. Structures shall comply with the latest edition of the Alameda County Public Works Agency Standard Guidelines (District storm drain lines only).

18. Pipes and boxes are to have rounded lip radii of 0.1 D at all entrances.

19. Structures are required where the lateral pipe diameter is greater than 1/3 the main pipe diameter.

20. Structures shall be channelized to 3/4 the thru pipe diameter for velocities in excess of 14 fps.

21. Maximum spacing of CB's or MH's is 400'. Gutter-flow shall not exceed 7-feet from face of curb.

22. Provide structural calculations and details for non-standard structures.

Pipes

____23. Minimum invert slope is 0.0007.

24. Flow from sidedrains are not to enter the main system at adverse angles.

25. Beveled RCP lengths must be specified (bevel one or both ends). B.C. and E.C. stationing and curve data are to be provided.

26. Minimum cover over pipes shall satisfy City requirements or shall be 3' unless special design and calculations are submitted.

27. Pipes carrying flows of 14.0 fps or higher shall be thick-walled RCP and have double rubber gasketed joints in fill areas and rubber gaskets or smooth, concentric joints in all other areas. The concrete protective cover from the inner surface to the reinforcement shall be 2" minimum. Corrugated metal pipe shall be paved for the lower 1/3 of the pipe.

28. Minimum pipe diameter is 12".

29. Pipes are not to have both horizontal and vertical curves at the same location. Show curve data.

Channels/Creeks

____30. Minimum invert slope is 0.0007.

____31. Maximum velocity in improved earth channels shall be limited to 6 fps. Minimum velocity shall be 2 fps.

32. Improved earth channel side slopes shall be 2-1/2:1 or less steep as specified by the project soils report.

33. Lined channel side slopes shall be designed to satisfy any concerns noted in the project soils report.

34. Note areas to be cleared of structures, trees, brush and debris within watercourses.

35. Watercourses to be dedicated to the District for maintenance shall comply with requirements specified in the Criteria Summary.

36. Building setback lines shall be indicated on the plans and location verified with X-sections (see Ord. No. 82-18).

Erosion Control

____37. Erosion control measures, if reviewed by the District, are to be designed to Association of Bay Area Governments standards.

The engineer will be notified should additional materials be required to complete the review process.

6/90

This memo shall serve as clarification of the requirements set forth in Section 2.9.2 "Detention Facilities" in the Alameda County Flood Control & Water Conservation District Hydrology and Hydraulics Criteria Summary.

For proposed development projects which are upstream of District facilities that were not designed to carry 100 year discharge or where proposed developments are upstream of a FEMA 100 year flood plain, post development storm water runoff must not exceed pre-development runoff for both the 15 and 100 year events.

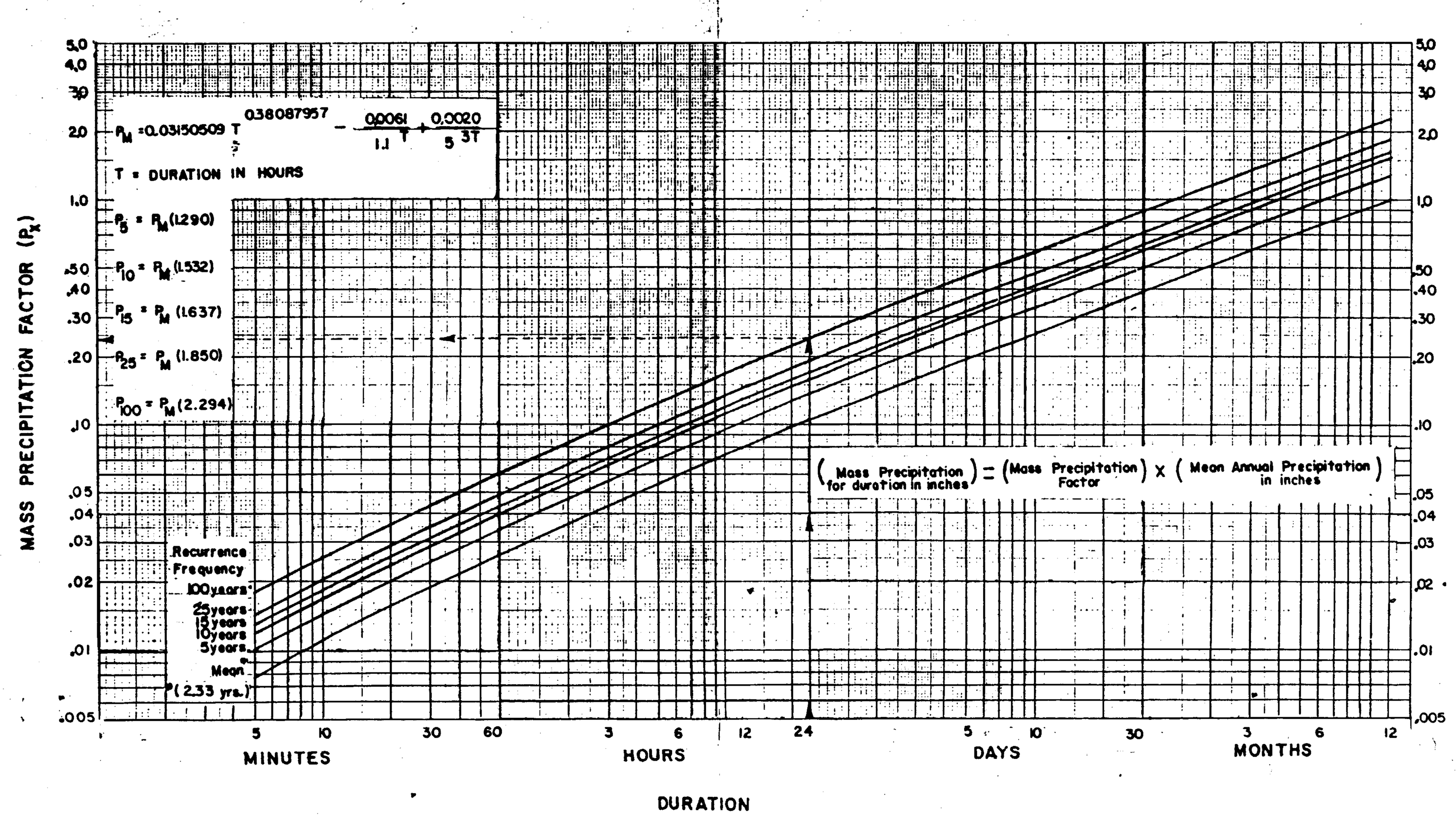
Analysis of pre-development runoff must be based on a thorough assessment of the existing land use, land cover, existing storm water holding facilities, including cattle ponds and naturally occurring ponding areas, and the existing on site conveyance system. Once the exiting runoff analysis has been approved by the District, the required detention pond facilities must be designed such that post-development runoff does not exceed pre-development runoff for both the 15 and 100 year events.

For smaller development projects, with post-development runoff of less then 5 cfs for the 100 year event, the requirement that post development runoff not exceed pre-development runoff for the 100 year event does not apply. For these projects, when the District determines that a detention pond is necessary, the pre/post development runoff limitation will be based on a 15 year event, however, the emergency spillway design must be based on the 100 year discharge.

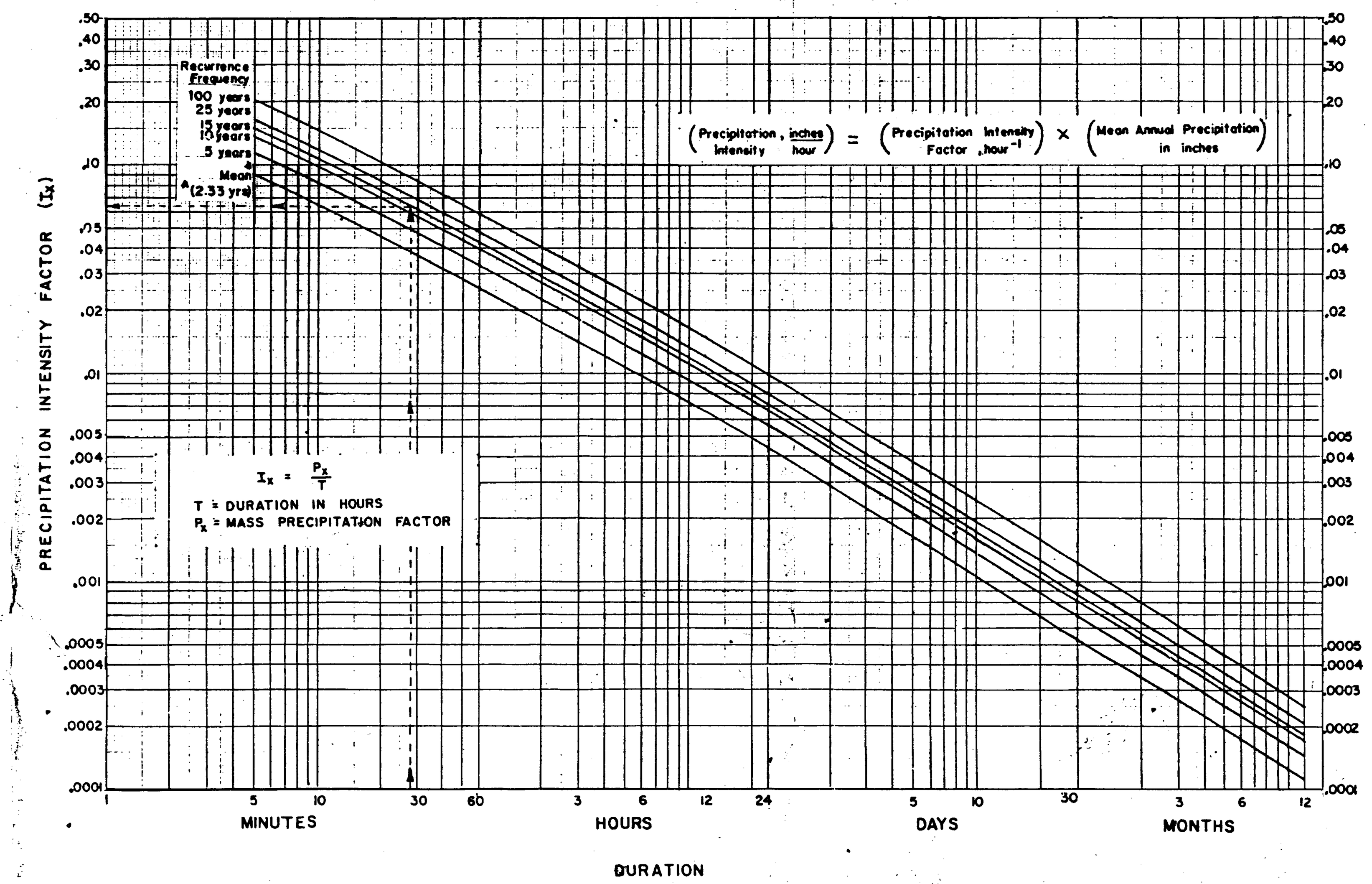
For infill projects with positive drainage, compliance with Hydrograph Modification Plan (HMP) requirements may be sufficient, provided that the site is not within a FEMA designated AH Zone and where there is no historic record of flood water ponding.

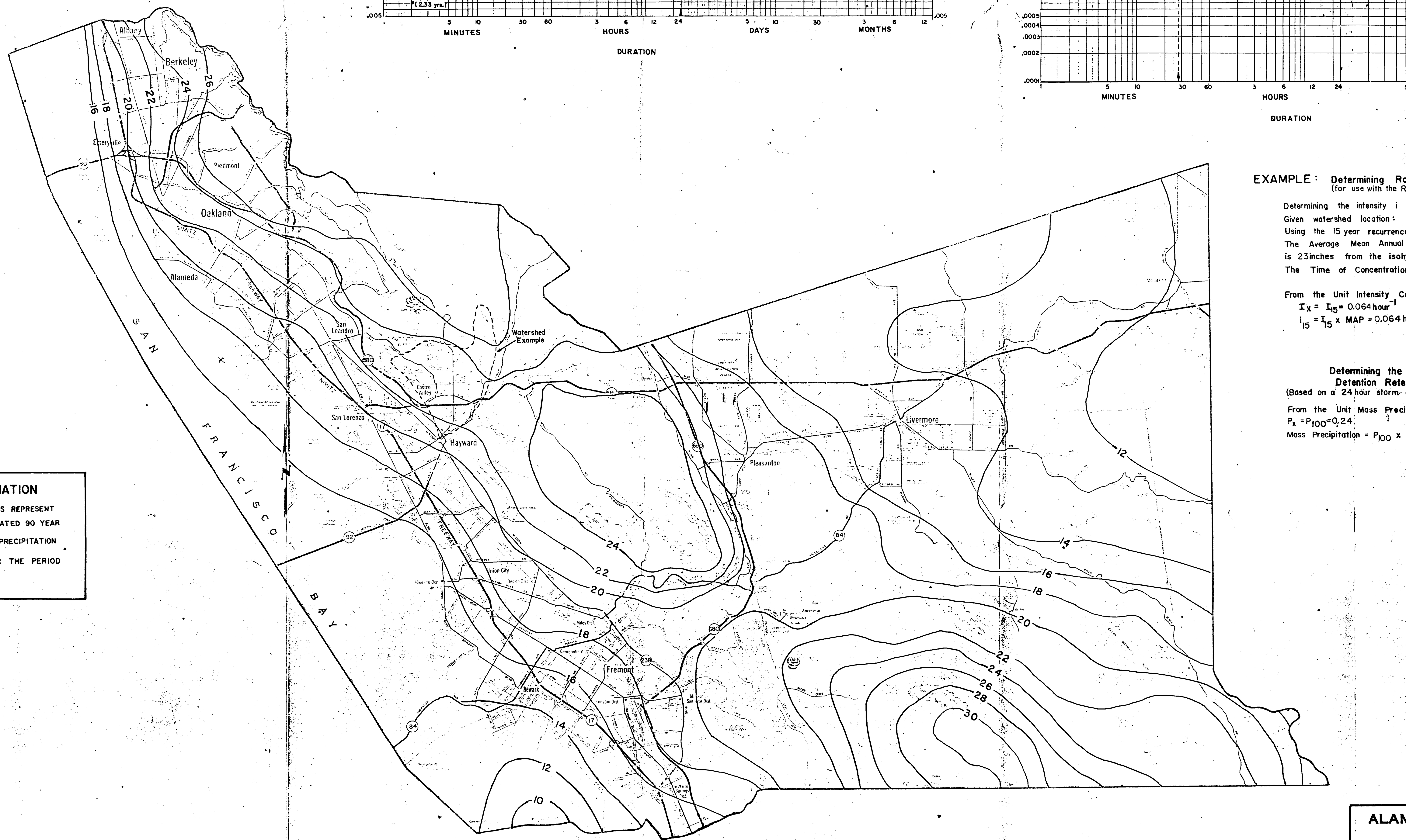
This requirement must be consistently applied in all Flood Zones and for all projects for which the District has required mitigation in the form of a detention pond.

UNIT MASS PRECIPITATION CURVES



UNIT INTENSITY CURVES





EXAMPLE: Determining Rainfall Intensity
(for use with the Rational Formula, $Q_x = Ci_xA$)

Determining the intensity i
Given watershed location: Castro Valley
Using the 15 year recurrence frequency.
The Average Mean Annual Precipitation (MAP) for the watershed is 23inches from the isohyetal map.
The Time of Concentration = 28 minutes (assumed)

From the Unit Intensity Curve
$I_x = I_{15} = 0.064\,hour^{-1}$
$i_{15} = I_{15} \times MAP = 0.064\,hr^{-1} \times 23in = 1.47 in/hr$

Determining the Mass Precipitation for Detention Retention Basin Design
(Based on a 24 hour storm duration, 100 year recurrence frequency)

From the Unit Mass Precipitation Curve
$P_x = P_{100} = 0.24$
Mass Precipitation = $P_{100} \times MAP = 0.24 \times 23in = 5.52in$

EXPLANATION

THE ISOHYETALS REPRESENT THE EXTRAPOLATED 90 YEAR MEAN ANNUAL PRECIPITATION IN INCHES FOR THE PERIOD 1888-1977.

ALAMEDA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

MEAN ANNUAL PRECIPITATION AND UNIT FREQUENCY-DURATION CURVES

REVISIONS				
5				
4				
3				
2				
1				
NO.	DESCRIPTION	BY	DATE	APPD

DRAWN	TRACED	DATE AUGUST, 1981	
CHECKED		SCALE 1" = 10,000'	
APVL. REC.		FILE NO. MA-180	SHEET NO. 1 OF 1
APPROVED			

DIETZGEN-POST CLEARPRINT 1000 H